BY THE SAME AUTHOR.

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Presented by
Col. Hehir

Nov 1911

PREVENTION OF DISEASE AND INEFFICIENCY IN INDIAN FRONTIER WARFARE.

PREVENTION OF DISEASE AND INEFFICIENCY

WITH SPECIAL REFERENCE TO

INDIAN FRONTIER WARFARE

BY

LIEUT.-COL. PATRICK HEHIR, I.M.S.,

M.D., F.R.C.P.E., F.R.C.S.E., F.R.S.E., D.P.H., (CAMB.), D.T.M., (LIV. UNIV.)

Officiating Principal Medical Officer, Burma Division.

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DEDICATED

BY PERMISSION

TO

HIS EXCELLENCY GENERAL SIR O'MOORE CREAGH, V.C., G.C.B.,

COMMANDER-IN-CHIEF IN INDIA.

PREFACE.

As bearing upon the bodily well-being of our Troops in India, both British and Indian, which has been to me the source of the greatest solicitude and interest, I welcome Lieutenant-Colonel Hehir's very full compendium of the laws relating to health with special reference to India.

It is a matter of general comment; and nothing has more insistently arrested my attention during my command in India, that an increasing interest in the prevention of disease has been awakened in all ranks by the diffusion of the elements of Hygiene and Preventive Medicine amongst them; and any attempt to add to the facilities for continuing this must have my warmest commendation and approval. With this in view I can but express the hope that Lieut.-Colonel Hehir's book will have a wide circulation amongst Officers and others in a position to profit by it and make its contents widely known and acted upon; and so I wish it every success.

Simla: O'M. CREAGH, Genl.,

8th September 1911. *C.-in-C. in India.*

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61.	16th line from bottom for *bearing* and *first* read *leaving* and *last*.		
62.	2nd line from top for *112* read *120*.		
65.	4th	„	bottom insert *to* between *explaining* and *them*.
87.	4th	„	top delete *springs*.
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122.	23rd	„	top insert *to* before *be*.
150.	7th	„	top for *similar* read *smaller*.
157.	15th	„	bottom delete *the*.
161.	3rd	„	bottom for *40* read *48*.
163.	last line for *400* read *500*.		
174.	23rd line from top for *assessory* read *accessory*.		
184.	6th	„	top for *figured* read *figure 1*.
192.	2nd last line of footnote for *beating* read *heating*.		
215.	24th line from top for *himself* read *themselves*.		
243.	6th	„	bottom for *in* read *on*.
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PREVENTION OF DISEASE AND INEFFICIENCY

WITH SPECIAL REFERENCE TO

INDIAN FRONTIER WARFARE.

INTRODUCTION.

A.—Brief Sketch of the Physical Geography of India and its Frontiers.

The science which teaches us the laws of health and the methods of their observance is called *Hygiene* or *Sanitation*. The term *hygiene* is derived from Hygiea,* the name of the daughter of Æsculapius, the God of Medicine of the Ancient Greeks. Amongst these people Hygiea was considered to be the Goddess of Health. The word *sanitation* comes from the Latin *sanitas*, which also means *health*. Sanitation is the science of preserving health by the prevention of disease.

Military hygiene deals with the principles and practice of sanitation as far as they concern the health and efficiency of the soldier, that is, it deals with the prevention of disease among soldiers in peace and war.

Wide scope of the subject.—The subject of the prevention of disease in peace times in cantonments and during our Indian Frontier Campaigns is a comprehensive one; especially is this so if we consider it inseparable from that of the physical training of our soldiers for war, and when we take into account the diseases likely to occur under the wide range of climatic conditions that obtain in our Indian Empire and our extensive Indian Frontiers.

Limits within which here considered.—Before proceeding further, it would be well for us to define the limits of the subject of military preventive medicine which we propose to consider. In the first place we will deal briefly with the physical characters of the main divisions of our Indian Empire, the extent of our Indian Frontiers, and their great diversity of climate and meteorology; then with the physical and general training of the recruit and developed soldier. Next we will take up the subject of *General Hygiene*, including in it the water-supply and food of the solider, air and ventilation, sanitation of

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* A Greek word meaning *health*.

barracks and cantonments, camp sites and camp sanitation; method of disposal of dry refuse and excreta on field service; followed by the *Personal Hygiene* of the soldier, embracing the subjects of cleanliness, clothing and equipment; the chief *Diseases* that occur in soldiers in Indian cantonments, on the march, during peace manœuvres, and in *Frontier Warfare and their Prevention*; the collection of Medical Statistics of campaigns and their uses; and, lastly, the duties of the *Medical Personnel* connected with the prevention of disease in troops in warfare.

In the part on *Diseases* one has dealt with only such as have an influence on the effective fighting strength of a force. The account given of these is in no sense exhaustive, and only such phases of the individual diseases as are necessary to explain the rationale of our preventive measures have been gone into.

It will be understood that it is not our purpose here to deal with the organisation or equipment of base or field hospitals with the force or on the lines of communication; nor is this the place to allude to any part of the actual treatment of the sick and wounded; and with regard to the medical *personnel* of the field force, only such remarks will be made as are necessary to make clear the respective duties of all medical officers, from the Principal Medical Officer of the Force to that of the medical officer of a unit in connection with the prevention of disease and inefficiency in the soldier. We will allude to the man inefficient from sickness only, in so far as he, by reason of suffering from infectious or communicable disease, or preventable acquired disease, may be a source of danger to the army, or a cause of inefficiency. The habits of the soldier will be alluded to so far as they affect his efficiency in the field, or by having been contracted in peace times, may affect his own health and that of persons dwelling with him.

To enable us to understand the foundations upon which our present-day preventive measures are constructed, it will be necessary for us to deal with a certain amount of elementary physiology and chemistry, the principles of general and personal hygiene, and to say a few words about bacteriology; and in doing so, one will endeavour to show how they are connected with the practical part of preventing disease in the field. It is first necessary for us to briefly consider some of the general geographical and climatic conditions of the area of territory included in the Indian Empire and its Frontiers.

The total area of British India is about $1\frac{3}{4}$ millions square miles. The shape of India on the map is that of a large triangle having its base on the Himalayan mountains and its apex running into the Indian Ocean. Its western coast is washed to a large extent by the Arabian Sea, and south of this by the Indian Ocean, its east coast by the Bay

of Bengal. It extends from the 8th to the 35th degree of north latitude, its greatest length is about 1,900, its greatest breadth being also about 1,900 miles. To this, for our purposes, is also to be added Burma, on the east shores of the Bay of Bengal. A line stretching from Karachi to Calcutta may for practical purposes be said to run with the Tropic of Cancer, the triangular peninsula of India below this being in the tropics, and the broad irregular area north of it in the sub-tropics.

The further to the south of the triangle the greater is the approximation to an equitorial climate, equability tending to two rainy seasons and no real cold weather. In the sub-tropical region we have a distinct cold and a hot weather, and one rainy season, and the farther north we proceed the more emphasised are these different seasons.

In a general way, if we exclude Baluchistan and Burma, we might divide India into three well-defined tracts:—(1) The *Himalayan region*, with which our Frontiers are concerned will be dealt with later on; (2) the region stretching southwards from the base of the Himalayas and comprising the plains of the great rivers which issue from them; and (3) the *southern tableland* or *Deccan*, which slopes upwards again from the edge of the river plains, and consists of a high three-sided tableland bounded by the Vindhya Mountains on the north, and by the Eastern and Western Ghats, which run down the coast on either side until they meet at a point near Cape Comorin. The three-sided tableland thus enclosed is broken by peaks and ranges interspersed with broad expanses of level uplands, and covers the whole of the southern half of the Peninsula of India.

The Indo-Gangetic depression forms a large area which includes the Punjab, Rajputana, and Sind in the north-west, the United Provinces in the centre, and a great part of the Province of Bengal, with the Deltas of the Brahmaputra and the Ganges, on the north-east.

"This great stretch of low-lying plain reaches from the Himalayas to the Indian Ocean on the west, and to the Bay of Bengal on the east, and includes the main arteries of the great river system of the Indus, Ganges, and the Lower Brahmaputra. The river system of this region is grouped into the Indus system on the north-west, and the Ganges and Brahmaputra on the north-east. The prevailing physical characters of the country comprising these two great areas of the Indo-Gangetic depression differ in many essential particulars; in the east there is endless irrigated fertility, but in the western arm a flat treeless landscape stretches like a broad grey sea to a level horizon."*

Between the Indus and the Jumna flow the five rivers of the Punjab—the Jhelum, Chenab, Ravee, Beas and Sutlej,—all of which unite to form the Panjnad, which joins the Indus near Mithankot.

* *Encycl. Brit.*, Vol. XII, p. 732.

The whole of the Indian Empire is for the purpose of classifying and compaing vital statistics of the army in India divided into 12 geographical groups, which are :—

(1) Burma Coast and Bay Islands ; (2) Inland Burma ; (3) Assam ; (4) Bengal and Orissa ; (5) Gangetic Plain and Chutia Nagpur ; (6) Upper Sub-Himalayan ; (7) North-Western Frontier, Indus Valley and North-West Rajputana ; (8) South-East Rajputana, Central India and Gujerat ; (9) Deccan ; (10) West Coast ; (11) Southern India ; (12) Hill Stations, Convalesent Depôts, and Sanitoria.

The Indian Empire included in these 12 geographical areas include great varieties in climate, embracing as it does the highest mountains of the world at one extreme, and extensive river deltas at almost sea-level at the other.

The northern or sub-tropical part of India possesses a large number of conveniently accessible hill stations, extending from Thandiana near Peshawar on the north-west to Darjeeling in the north-east, which serve the very important purpose of giving habitation to a large number of our European troops for at least part of the hot weather. These have all elevations of over 5,000 feet, some over 7,000. The southern or tropical triangle contains but few of these—the most important being Panchgani in the Western Ghats, and Wellington in the Nilgherries.

Territorial boundaries of the Frontiers of India.—Roughly speaking, the territorial boundary of the Frontiers of India may be said to begin at a point about 400 miles west of Karachi (at the south-western extremity of Baluchistan) ; thence it traverses in a northerly direction the arid plain of Baluchistan, with its extremes of climate (in which a diurnal range of temperature of 80° Fahr. is not unknown),* until it approaches the Seistan Swamp ; and bearing due east until it strikes the Suliman Range, which it follows in a north-easterly direction following a short westerly deviation, to include the Kurrum Valley, it strikes the Safed Köh, and courses along these impassable mountains until it reaches the Khyber Pass. Thence it travels in a northerly direction through Jumrud on the Cabul River, until it comes to the Hindu Kush, which it follows up to its junction with the Great Karakorum Range. The frontier here passes through immense altitudes with an intensely cold climate, and arrives at the southern extremity of the Pamirs. From the Karakorum the boundary dips south-west across the upper reaches of the Indus, until it meets the stupendous Himalayas, which form its northern limit as far as Kumaon. Here it makes a southerly curve and runs practically east along the malarious Terai of Nepaul, Sikkim and Bhutan, parallel with the Himalayas, until it meets the Brahmaputra rapids north of Sadiya (Assam). It now proceeds eastwards along the conventional boundary between Thibet and Burma for about 200 miles, until it reaches the watershed between the Salween and Mekong rivers. Thence it runs south to a point about 50 miles from Bhamo, on the Irrawaddy. From here it takes, in a general way, a south-easterly direction, until it meets the Mekong River, passes along that river as far as Khiang-Sen,

* This range of temperature in 24 hours has been registered in Quetta.

at which place the boundaries of Burma, Siam and French Anam meet. Thence it takes a westerly turn, along a range of hills on the left bank of the Salween, which it follows, generally due south, to the Isthmus of Kra.*

Varying meteorological and climatic conditions.—Regarding meteorological conditions on our Indian Frontiers, we may have at different times of the year variations ranging from intense tropical heat as in the Burma Wars, Malakand, and other expeditions, to almost Arctic cold, as in the Khanki Valley in Tirah, and in the later stages of the Thibet Mission. Such variations may all happen in the same expedition, even when it is of comparatively short duration. The march from Kushalgarh to the Samana through Kohat, in September and October 1897, was extremely hot and responsible for some cases of heat-stroke. In December the cold was intense in the valleys between the different ranges of hills. The possible vicissitudes of climate and weather through which our troops may have to travel was well demonstrated in the Thibet Mission, which, starting from the railway terminus of Siliguri 1,306 feet above sea-level, went through the Terai, then the gorge of the Testa River, and up its malarial channel to Upper Sikkim, finally passing up to heights reaching 16,700 feet. "The climate to which the force was exposed was unprecedented in its rigour and range. These extended from the tropical climate of the Terai and lower Testa Gorge to the Arctic cold of the great passes, and the inclement Thibetan winter, combined with the trying effects of the rarefied air of these immense altitudes on the respiration and heart. The cold frequently was positively painful, especially when the wind blew. The lowest temperature recorded during the winter was on the Jong Pass on the night of January 7th, when the thermometer registered minus 26° Fahr., or 58° below the freezing point. The garrisons at Phari and Tuna, and the convoys which daily crossed the passes, led a miserable existence all winter, tormented by the cold and icy wind and altitude. At Gyantse, snow fell during every month of summer. The rainfall was considerable. Yet with all this, the general health of the troops was very good. The greater portion of the sickness and deaths was unattributable to climate."

Persistent inclement weather.—It may happen that the force is assailed by persistent bad weather—severe cold, rain, sleet, snow and storms as happened in the Miranzai Expedition of 1891, which owed its low sickness rate to the foresight which provided all men with tents, excellent warm clothing, water-proof sheets, and such beverages as warm tea when necessary. Or, that a column has to move rapidly or fight in a burning sun for days—the result of the former as regard heat-stroke in the 35th Sikhs in their march between Nowshera and

* I am indebted to Capt. C. P. Barlow, 2/8th Gurkha Rifles, for his help in working out the above boundaries.

Malakand to the relief of Malakand in 1897 is still fresh in our memory. Or, the force may have to pass through a dry, arid, hot and sandy country, as occurs along much of our North-Western Frontier, or one in which rain falls for several months of the year, as our North-Eastern Frontier. Or, again, one which is hot and enervating from its high degree of humidity, as in Burma and Assam, or one that is dry and stimulating as in Baluchistan, Chitral, and the Punjab generally.

Intense cold, effects of.—Even intense cold may be endured by healthy troops without much hardship or inefficiency, from this cause alone. SCOTT in the South Pole Expedition, with his staff and men, spent a whole winter many degrees below zero, and in darkness, with only an occasional case of frost-bite ; NANSEN and JOHANSON spent two winters in their North Pole Expedition, and both actually gained in weight. Troops when well clothed, well fed, and provided with warm shelter, will tolerate cold without injury. In Tirah, the nights were frequently below zero in the Khanki Valley early in December, and even in Karruppa late in November ; yet one never had a case of actual frost-bite amongst the troops, although some followers suffered, and the latter rapidly succumbed to disease predisposed to by the cold.

Vicissitudes always trying.—Vicissitudes of climate are trying, extremes of climate always so ; but they do not affect the fighting vigour of our troops so long as they are in good health.

Provision against climatic influences.—Regarding meteorological conditions we may state that whilst accidental, and even normal conditions of climate, and extreme meteorological vicissitudes of weather—snow, rains, low temperature, and tropical heat, have occasionally operated disastrously on the health of troops and transport animals, on the whole, such disasters are almost always to some extent attributable to want of foresight in not preparing for ordinary possible contingencies. The grave lessons in the history of Napoleon's invasion and retreat from Russia in 1812 show that natural causes were responsible to only a limited extent. Frost was a severe enemy even in our campaigns in the Peninsula of Spain and Portugal, and it is on record that alcohol increased the dangers from bad weather during that campaign. With reference to this latter point we might state that all experience, including that of several Arctic and Antarctic expeditions, teaches that the use of alcohol to overcome the effects of cold is a fatal error. No fewer than 150 of King Joseph's French guards were frozen to death in the Guadanama Pass, and the sufferings of Alexander's army, morally and physically, in the Caucasus, when surrounded by what seemed eternal snow, are historical facts. Our troops in Thibet went through the most penetrating cold for months, but they had suitable clothes, posteens, Gilgit boots,

and abundance of blankets at night. "Climate remaining the same, the inefficiency from mortality and disease varies with the perfection of the hygienic arrangements." This holds good both in peace and war. In peace the effects of improved sanitation have been shown in the progressive decrease of sickness and mortality in the army in India, in the West Indies, in the British Isles, in the French in Algiers and Tonquin and in other European armies with colonial possessions. We have also several instances of war showing the advantages of improved preventive measures such as the Hazara Campaign, the recent Thibet Mission, in the Germans in '70 and '71, the Japanese in the late war, etc.

Forethought and comprehensive organisation required on part of Medical Service.—The conditions of warfare on our Indian Frontiers are so varied, and the contingencies to be met so numerous, that to provide successfully against all possibilities as far as the medical branch of the service is concerned in every expedition, much forethought is needed. Every medical officer, from the last joined subaltern attached to a field hospital, to the Principal Medical Officer directing the comprehensive medical organisation of a whole campaign, has his personal responsibilities in the success of the operations, and once the campaign is opened, one and all have to brace themselves to a strenuous task. The Principal Medical Officer and sanitary and other medical officers concerned, will have thought out the conditions of meteorology and climate to be dealt with, the question of the clothing, food, water-supplies, camp sites, sanitary organisation in camps, the diseases likely to harass the troops, the care of the sick and wounded, the method of getting those *hors de combat* to the base, and all the other questions that can affect the health and well-being of the command.

In proceeding against a powerful enemy with modern armament and one requiring all our resources to be put in operation at an early date, the strain at the beginning of a campaign will necessarily be great; and every medical officer with the force will be obliged to put forth every effort to prevent anything in the shape of a breakdown in the medical arrangements. Everything should as far as practicable be thought out beforehand, and preparations made to meet all reasonable contingencies. Every endeavour will be made to press forward all medical and surgical equipment, and *personnel* likely to be required with the force. During an outbreak of epidemic infectious or communicable disease, the resources of the medical department will be specially strained; during such times every medical officer with the force in which such disease occurs must exert all his energies and skill in endeavouring to eradicate the disease as speedily as possible, while the administrative medical officers will formulate a plan of campaign against the disease with the same object, and issue orders to all concerned thereon.

An epitome of the Medical History of our Campaigns a desideratum.—As with the combatant branches of the service, the medical should in peace times be constantly employed in the work of preparing for all possible contingencies likely to arise during war. In this connection it has struck one that a valuable instructional work might be compiled in the shape of a collective abstract of the medical histories of all our Indian Frontier Wars of the last 60 years. The value of the lessons to be derived from these histories would be enhanced by abstracts of similar reports of our wars in other parts of the globe, and of those of the leading armies in Europe, in America and Japan, and of armies who have fought in tropical and sub-tropical regions, during the period named. Some such record might then be made available to every military medical officer for guidance.

It is well known that long before the out-break of the recent war Manchuria was carefully explored as to its sanitation by the Japanese. The information thus acquired helped to reduce to a minimum the usual epidemics of campaigns, and to achieve what no other nation has hitherto attained to in this respect in a large campaign.

Work of Japanese Medical Officers in Manchuria.—All recorded evidence shows that the medical and surgical work of the Japanese Army in Manchuria appears to have been phenomenal. Their medical officers are said to have been ubiquitous. They were seen in places where ours never go—as much in the front as in the rear. They were with the first screen of scouts with their chemical apparatus examining water, labelling and permanganating water-supplies, when necessary, to ensure the following army a pure supply. When the scouts reached a town, the medical officer at once began a sanitary inspection. If infectious or contagious disease existed he quarantined the place, and posted a cordon of sentries at a safe distance from it. Notices were posted down the line, warning the approaching army of the existence of such disease. A fully equipped bacteriological apparatus was with every division. In camp he was seen to be lecturing to the men on sanitation, the prevention of disease, personal hygiene, cooking, when to drink and when not to drink water, even to cleaning and paring the finger nails, to prevent dangers from dirt, etc.

All officers, etc., can help in preventing disease.—Every British officer, native officer, and non-commissioned officer with a force, can help in preventing inefficiency from disease by seeing that their men observe all sanitary and hygienic rules prescribed for their guidance and welfare on field service. Every officer of every unit, from the last joined subaltern upwards, has his personal responsibility in preventing disease in the men. The health of the force depends on the rigid observance of the sanitary precautions and rules laid down, and it is directly in proportion as commanding, medical, and other officers of units insist on such observance, and devote personal attention to them, that the troops will remain free from preventable disease. The general guide to all preventive measures is, of course, the *Field Service Manual, Medical*. It is impossible, however, for any formulary of regulations, no matter how complete, to embrace all possible contingencies; hence with each campaign certain modifications or additions will be necessary, and such additions will be published both before taking the field, and from time to time during the campaign, as circumstances require, but apart from what is definitely laid down in regulations, there will always

be occasions on which all ranks of the Medical Service must act on their personal judgment.

Sanitary Administration, Delhi Durbar, Rawalpindi and Agra Concentrations.—One has personally had the unusual experience of doing duty with our last three large concentrations of troops in India—the Delhi manœuvres of 1902, Rawalpindi manœuvres of 1905, and at the Agra concentration of 1907, and one has no hesitation in stating that the sanitary administration of our army in India is on a totally different basis, and on an incomparably higher level, than it was 20 years ago; and one is confident that if it continues to be carried out in our future wars, as it was on those three occasions, cases of preventable disease will be considerably fewer than in previous campaigns. One would here remark that, in the field, if responsible Sanitary Medical Administrators be given a free hand under the General Officer Commanding, with power to carry out what measures they consider necessary to ward off preventable disease, there is no doubt as to the beneficial results that must follow. The work of Sanitary Officers is based on grounds which, although not those of an exact science like mathematics or astronomy, are the nearest approach to it that pathology, etiology and preventive medicine generally, in the present state of our knowledge, permit of.

Duties of the State to the soldier in the field.—It is necessary to remark that the State is bound under the conditions we enlist our European and Native troops, to place them in the best practicable conditions of health and safety from disease during war. To do so is to the advantage of the State. The fighting power of the soldier employed depends on the standard of health and physical vigour he is kept in. On the other hand every soldier has in this respect his personal responsibilities, and it is for us to point out to him what these responsibilities are.

B.—Climate of India.

By climate of India we here mean the complex series of meteorological conditions which occur in this country and their effects on the health of our army.

The character of the climate of any locality depends mainly on:—Its distance from the Equator, elevation above sea-level, its relation to adjacent seas, large bodies of water, sandy deserts, marshes, predominating winds, nature of the soil (whether rock or dry and porous ground, such as sand allowing rapid percolation of moisture, or clay, etc., which is more or less impenetrable to water), configuration of the surface, amount of shelter—on a slope, plateau, in a valley, aspect towards the sun, etc., method of cultivation of the soil—whether the surface is richly cultivated, covered with plantations or trees, pastures, dense forests, or more or less bare, facilities for drainage, and the amount of artificial cultivation of the soil practised.

The chief meteorological factors effecting climate are—*atmospheric temperature, humidity of the air*, and the *amount of rainfall.*

Temperature.—In forming an opinion as to the characters of a given climate, temperature of the air is by far the most important factor.

The latitude of a place is the main determiniug cause of its temperature, although a glance at any isothermal chart of India* will show that this is only true in a general way.

The isothermal chart of India shows that the lines are in no way parallel with the zones of latitude. The isothermal line corresponding with the average temperature of India is seen to be very irregular in outline. This is easily understood when we recognise that the areas included in the isothermal lines embrace very irregular distributions of land and water, mountain and valley, fertile districts and barren sandy plains, which absorb and radiate solar rays with varying degrees of rapidity, exposure to winds in a varying degree, and for other reasons. These varying physical conditions give different climates.

As a rule, the nearer a locality to the Equator the hotter it is, because the solar rays fall more vertically than in. higher and lower latitudes, and the sun's rays have a shorter distance to travel than wheu more adjacent to the poles.

Regarding temperature we should differentiate between *radiant* or *sun heat* and *shade* or *air heat.* The rays of the sun heat the human body and other things they fall on, but only slighty warm the air through which they pass. The air would allow the heat to pass though it entirely were it not for the watery vapour and the sand, dust, etc., it contains. The more vapour and other added bodies the air contains, the less powerful is the direct or radiant sun heat. The shade temperature is chiefly due to the warmth imparted to the air from the ground (including water and land) previously heated by the sun's rays. The shade temperature may, however, be greatly influenced by currents of air from distant parts, *viz.*, warm or cold winds.

The heat depends on the direction of the sun's rays, the vertical being very hot, the oblique being cooler. It also depends on the depth of the column of air. At the sea-level this column is deepest. The higher we go from the sea-level, the more rarefied the air becomes, and the less the heat of the air due to solar rays Heat is also modified by proximity to warm or cold sea currents, proximity to mountain ranges, by the nature of the soil, direction of the prevailing winds, relative humidity, amount of vegetation, etc.

It is essential to distinguish between *effects* of the radiated or sun heat and shade heat. It is not possible to state with our present knowledge what actual degree of sun heat can be borne by the body. Sunstroke is rare in the pure and comparatively dry air of high elevations. High shade temperature is much less easily borne, and people who can work in a sun heat of 130° Fahr. or so, become soon exhausted with the same work in a shade temperature of 100°—105° Fahr. But this question is complicated by the fact that we are unable to differentiate the effects of temperature *per se*, from those of moisture, electrical state of the air, etc. People tolerate heat very differently, and the manner of living influences their ability in this respect;

* A map of India with a series of lines, these lines passing through places having a corresponding temperature.

many Europeans living in India injure themselves by continuing to take the same kind and amount of food and stimulants they did at home, a fact pointed out by many great authorities on the military hygiene of India during the last sixty years. It seems, however, that great shade heat has a depressing influence, lessening the functions of digestion, respiration, circulation and blood formation, and directly or indirectly the formation and destruction of tissues.

The climate and temperature are largely affected by the amount of humidity in the air and the amount of rain the locality receives, the situation of the locality, whether it is inland, on the sea-coast, on the plains or hills The coast has a more uniform temperature ; the abundance of rain and amount of watery vapour in the air on the coast prevents extremes of temperature. It is seldom above 90° Fahr.

The actual surface temperature of the ground in certain parts of India often reaches 170° Fahr. or higher during the hot weather, whilst that of water is seldom over 80° Fahr. During the day when the rays of the sun are powerful the air near the soil gets heated, expands and rises more rapidly than the air over the sea, hence to fill the place of the ascending air from the land the cool air from the sea rushes into the land in the later part of the day. At night the reverse occurs. Land gives off its heat more rapidly than the sea and gets cooler than the sea from which latter the air ascends, hence there is a breeze from the land to the sea, so that in the early morning a breeze blows from the land to the sea. This is only felt in the vicinity of sea coasts and does not affect the great inland continent of India. All large sheets of water inland however, have the same effect, and tend to equalise the temperature of the air in their neighbourhood.

The geological nature of the soil affects the temperature. Generally the soils which absorb most heat give it out most rapidly—hence sandy soils are hottest and associated with the hottest air temperatures. Clay soils, on account of retaining water, are coolest.

The specific heat of soils varies very much, any water contained in it raising this proportionately. Hence damp clay soils are cold because they take some time to warm. Sands absorb heat very rapidly and lose it again by radiation. "In Upper Egypt the effects of the withdrawal of heat after sundown is remarkable. So so rapid, indeed, is radiation aided by the cloudless atmosphere, that sleeping out without extra covering is productive of a degree of discomfort suggestive of being steadily frozen alive. It was no uncommon circumstance, during desert marches, to see men, who were unable to sleep from the cold, prowling about in the small hours of the morning in the vain hope of getting warm. During the day the conditions were so far reversed that the intensely heated sand raised the temperature of the lower stratum of the atmosphere to a degree approximating to that of the air from a blast furnace."*

The colour of the surface of the soil has a great effect on the amount of heat which is absorbed and reflected. The nearer the colour of the ground approaches to white (sand, white walls, etc.), the more the direct sun heat is reflected by it, and the less heat is absorbed ; the darker the ground (grass, green leaves), the less heat is reflected and the more is absorbed. The ground and buildings which absorb more heat from the direct rays of the sun can give out more heat during the night and *vice versâ.*

* Lt.-Col. R. Caldwell, R.A.M.C., *Military Hygiene*, pp. 269, 270.

The following table gives the maximum, minimum and mean shade temperature in some of the more important cantonments of India:—

Stations.	Maximum Temperature.	Minimum Temperature.	Mean Temperature.
Lucknow	115°F.	70·5°F.	99·3F.
Meerut	115	80·7	98·3
Agra	114·5	77 5	96·7
Jhansi	116	80·1	99·2
Multan	117·3	78·5	79·8
Lahore	116·9	70·7	95
Peshawar	117·2	67·9	94·1
Karachi	99·9	80 2	88·8
Bombay	94	77 5	85
Madras	117·5	77	92·4

At Jacobabad in Sind, which is about 500 miles north of the tropical zone, a shade temperature of 127°F. has been registered. Shade temperatures of 115° are quite common in several stations in the sub-tropical regions of Northern India.

The germs of some diseases grow more vigorously in high temperatures; for instance, cholera and plague bacilli, and the germ of dengue (as yet undiscovered), but the germs of some infectious diseases prove stronger than climatic influences, hence we find such diseases as small-pox, measles, diphtheria, tuberculosis, leprosy, etc., in all climates.

Humidity.—Next to temperature in importance is humidity. This we refer to under the terms *absolute* and *relative humidity.*

Absolute humidity is the actual weight of watery vapour in a given quantity of air. When air is heated it expands, and so its capacity for holding vapour increases rapidly. A cubic foot of air at zero Fahrenheit can hold only 0·54 gramme of water, at 32°F. 2·13 grammes, at 50°F. about 4 grammes, at 80°F. about 11 grammes, and at 100°F. 19·79 grammes.

Relative humidity is the amount of watery vapour contained in air relative to what it could contain, the standard maximum being 100 per cent. The lowest relative humidity is said to be 25 per cent.; under 55 per cent. it is said to be dry, under 75 per cent. moderate, over 85 per cent. damp. Relative humidity is important only when taken into consideration with the temperature, because warm air takes up more watery vapour than cold air.

When statistics of relative humidity alone are given in meteorological tables, it is necessary to take some standard temperature to make

a fair comparison. Say the mean temperature of the plains of India is 82°F., a relative humidity of 55 per cent. would be dry, from 65 to 75 medium, and from 75 to 85 moist, above 85 very moist.

The best degree of relative humidity for the human body of inhabitants of temperate climates is 75 per cent. If much in excess of this skin perspiration and evaporation from the lungs are to some extent checked, thereby favouring the retention of effete products. Deficient humidity induces increased evaporation from the skin.

The degree of the absolute humidity varies with the seasons and at different times of the day; it is usually greater with higher temperatures and *vice versâ*. The variations of relative humidity as a rule follow to some degree the opposite course: the relative humidity is lower in the hot than in the cold weather, and lower during the warmest parts of the day than at night. The importance of temperature should never be forgotten in estimating the value of relative humidity in connection with climate.

Watery vapour is always present in the air, but its amount varies within extreme limits, and its amount is constantly changing by the perpetual processes of condensation and evaporation in progress. Humidity greatly modifies the heat. When the relative humidity is high, the watery vapour in the air acts as a blanket over the land, preventing great penetration of heat rays, speedy evaporation and radiation; hence the diurnal variations are small and the climate more equable. With a low relative humidity and a dry air, evaporation and radiation are rapid; the soils most absorbent of heat during the day cool rapidly at night, and the climate is subject to great diurnal fluctuations. The great amount of watery vapour in the air and the (usually) heavy rains near the equatorial regions of India give an equable but not excessively high temperature. Hence it is that in the more southern parts of India we have no real cold weather comparable with that in Northern India.

The larger the surface of exposed water in a locality, and the smaller the proportion of land, the greater is the equability of its temperature and *vice versâ*. This is due to the fact that water requires a large amount of heat to raise its temperature, and when warmed it parts with that heat slowly, whereas land warms rapidly and cools equally soon. No matter what the degree of radiant heat, it is seldom we find exposed sheets of water raised above 80°F., whereas it is not uncommon to find the surface of adjacent ground fifty degrees higher. Water absorbs heat slowly and parts with it slowly; land absorbs heat rapidly and parts with it rapidly.

The heat of the sun is tempered greatly by passage through the watery vapour of the denser air.—Watery vapour in the air interferes with the passage of solar heat rays to a degree equal to the extent to which its own temperature is heightened; the deeper the atmosphere penetrated by the sun, the less the heat reaches the earth. In consequence of the greater rarefaction of the air, the higher we are, the greater the loss of heat by radiation, the lower we are the less.

The temperature and humidity of the stratum of air lying immediately over the soil are modified by the intrinsic qualities of the soil. These qualities vary greatly. Dry clay can absorb its own weight of water, dry garden soil (mould, etc.,) about one-half and sand about a third. Sand dries most quickly, garden soils less so but quicker than clay.

The amount of rainfall has no definite relation to the amount of moisture in the air—Lima, on the coast of Peru, has a very humid atmosphere, but is almost rainless.

It is difficult to separate the effects of different degrees of air moisture on man from those of temperature, light, atmospheric pressure, and movement of air. In dry air the evaporation from the skin and from the lungs is promoted, and this effect is increased, if, at the same time, the sunshine is powerful, as in elevated regions. In moist air both are diminished. In moist warm air the appetite and vital energies are lessened, and there is often a tendency to affections of the abdominal organs. The growth of microbes is favoured in such localities, and this is one of the reasons possibly why tuberculosis is so prevalent along the sea coast in India, cholera along the delta of the Ganges and other rivers, dysentery along marshy tracts, etc. Speaking generally we may say that germ-diseases are more active in hot than in cold climates, and in damp than in dry ones.

Where vegetation is luxuriant there is increased humidity of the air and soil, and this without necessarily greater precipitation of rain. Vegetation generally, especially trees, has a cooling effect upon the soil both by sheltering from the direct rays of the sun, and by increasing evaporation.

Rainfall.—Rain is due to the cooling down of air to such a degree that it can no longer hold the watery vapour it contains in a state of suspension, consequently the vapour is condensed into droplets which fall on the earth as rain.

The distribution of rain is an important factor in the varying climates of India. The nearer the Equator and to the sea, the greater the rainfall. Where rains and moisture are abundant the climate is not excessively hot, but it is steamy damp and oppressive, and the range of temperature limited. When the rainfall is scanty the climate is very hot and dry in summer, and the range of temperature large. Between these two there is every variety of climate approaching to one or the other.

The chief characters of the Indian rainfall is that it is periodical and regular, containing usually for three or four months only, occurring mostly as decidedly heavy showers, sometimes 6 to 12 inches or more falling in 24 hours. Where the soil is not very porous, or has not natural facilities for rapid drainage, the result is the occurrence of floods, inundations, and the formation of extensive swamps.

In India the rainy season is regulated by the monsoons, which are the two predominating winds of the continent, the South-West Monsoon and the North-East. From October to March the North-East Monsoon prevails; it is a cool and dry wind, having passed over vast tracts of land. From April to October the South-West Monsoon occurs; it is a hot wind charged with moisture from the southern sea, and for three or four months of the year brings rain to the greater part of India. When the sun is vertical in the Northern Hemisphere, there

is a gradual heating up of the land until it becomes exceedingly hot. With this intense heat the barometric pressure is gradually lowered and air currents from the southern seas rush into the vacuum, passing in the main in a south-westerly direction. Laden with moisture this South-West Monsoon when it strikes the high highlands, as in the Western Ghats or on the Malabar Coast, on the mountains of Tenasserim and the Himalayas, where it meets with colder air, deposits its moisture in the form of heavy rain, reaching as much as 253 inches in the year at Mahableshwar, 180 inches at Moulmein, and even 600 inches at Cherapunji (Khasia Hills, Assam). Having lost much of its moisture in its passage over the highlands, the inland districts may be comparatively dry. Or, even in places near the sea, where there are no highlands, the rainfall may be small as at Karachi (7 inches).

The rainfall not only varies within wide limits in different parts of India, but also in different years.

The rainfall of Sind proper and the Lower Indus region is about 5 inches, and the heat from April to July is very intense.

In the rainless tracts of Sind and Western Rajputana we find an absence of vegetation which exposes the surface of the ground to the intense rays of the sun, the sand rapidly absorbing the heat, there is rapid radiation at night, and frequent sand storms.

The following table gives the average rainfall over the chief districts in which it is measured :—

	Inches.		Inches.
Assam	99·55	Central India, West ...	34·62
Eastern Bengal	85·21	,, ,, East	45·65
Orissa	57·73	Berar	31·32
Chota Nagpur	53·4	Central Provinces, West ...	52·88
Behar	49·38	Bombay, Deccan	32·17
United Provinces, East ...	40·10	Hyderabad, North	35·81
,, ,, West ...	38·85	,, South	29·72
Punjab, East and North ...	23·97	Mysore	34·61
,, South-West	8·89	Malabar	128·68
North-Western Frontier Provinces	16·36	Madras, South-East	35·66
Baluchistan	8·63	,, Deccan	24·79
Sind	6·63	,, Coast, North... ...	40·45
Rajputana, West	11·81	Lower Burma	122·86
,, East	25·16	Upper ,, ...	41·51
Gujerat	35·06		

Proximity to mountain ranges and their influence of sheltering from wind and on rainfall, soil and its permeability to moisture, and vegetation, also exert an influence on climate.

The whole of the coast of Burma has a very moist warm climate which affects the inland area to but a small distance, as the moisture from the sea is precipitated on the high range of hills that extends along the entire length of the western part of the Peninsula through Arracan, at a short distance from the coast, so that as we ascend the Irrawadi the rainfall lessens until in the higher reaches of Upper Burma we get a climate reproducing many of the characters of North-Western India, but less marked. The higher rainfall of Bhamo as compared with Mandalay is attributable to its proximity to the great range of hills which divide Burma from China.

The nature of the vegetation in some parts of India is sufficient to indicate the nature of the climate. Where it is richest and most luxuriant there the climate is hot and moist, and the seasons equable, *e.g.*, Assam. In such places a deserted village may in a year be hidden from view by the rich growth of vegetation around it. With less but still rich vegetation the climate will be hot with abundance of rain, as in Behar. In regions where the temperature is very high and rain fails the vegetation fails also, and the land has the characters of a desert; these are the climatic peculiarities of Sind, Western Rajputana and part of the Punjab.

Exposure to winds—Winds are caused by unequal weights of different volumes of air; warm, light air ascends, and cool, heavier air rushes in to take its place. Hence there is a constant inrush of air from the cooler to the warmer parts. Plains are exposed to uninterrupted sweeps of wind as seen in the summer storms of these places.

In many districts, and even in whole provinces, we have, as the result of great heating of the surface soil, great heightening of the temperature of the air near the surface, with the result that areas of low barometric pressure are created, to counteract which air converges from all sides and takes on a circular motion, or vortex, round its centre. The disturbances created may extend many miles, or be quite local, and small disturbances varying for 50 to 500 yards in diameter are particularly common in May and June in Sind, Rajputana, and the Western Punjab. These are in fact miniature cyclones, depending on the same physical laws for their occurrence. The vortex revolves in the opposite direction to the hands of a watch, the motion being not truly circular but spiral in such manner that a particle carried by the wind, after circling round the centre several times, ultimately finds itself carried to the centre of low pressure. In the same way the centre of low pressure with its accompanying vortex always travels at first from east to west, and then curves away from the Equator, to ultimately take an easterly direction as it dies out. The dimensions of the vortex, and the area influenced by such storms, may vary from a few yards to several hundred miles, but in all cases their force within the vortex is very considerable. After a period of exceptional heat and stifling calm the still leaves of the dried-up trees are agitated by light puffs of air of irregular direction, then away in the east is seen a column of dust, and this steadily advances till one finds oneself for a few minutes buffeted by a violent fiery wind and choked with dust. When it has passed and the air has again cleared, this is succeeded by a refreshing relief of the previously intense heat. When of very small dimensions these miniature cyclones are locally known as "devils" and their form, narrow below and spreading out like a funnel above, can be studied at leisure. The boundaries of the expanded upper part are indistinct and fade gradually into the steel-grey of the surrounding glare; but below the contour of the column is well nigh as sharp as if it was composed of solid materials, and it may sweep

along close by the observer without involving him. When of larger dimensions, so that the boundaries of the revolving column of dust and air are beyond the range of vision, they are known as "dust storms," and in spite of the temporary discomforts they cause are gladly welcomed on account of the relief they bring from the suffocating heat that originated them. From a sanitary point of view these storms are usually beneficial by their effect in clearing the air and cooling it; but this is unfortunately only trifling and temporary.*

Rapid putrefaction and fermentation.—The lower forms of vegetable life thrive in India, especially in the hot and moist regions. This is undoubtedly good for the visible vegetable kingdom, as these organisms break up organic matter, and fit it for plant life. But for the same reason disease microbes thrive. Putrefaction and fermentation are much more active than in temperate climates. The same meteorological factors favour the development of germs and parasites which give rise to diseases almost peculiar to the climate. Certain regions of the globe have their own microbes and parasites in which these latter flourish best. The germs of such diseases thrive best in their endemic homes, finding in them congenial conditions for their development, just as plants and different races of men flourish best in their original homes. Hence we find the home of cholera in the delta of the Ganges, malaria throughout the country because the endemic conditions are favourable to both anophelines and malaria parasites; filariasis is met with almost universally for the same reasons, and so on with other diseases.

Sunlight.—Sunlight is of great importance in climates. It is well known that a few dull sunless days have a depressing effect on some people, reducing energy, inducing dyspepsia, and with returning sunshine these effects pass off. Sunlight hinders the development of bacteria and other low organisms, and increases oxidation. The effects of sunlight are more intense in dry air and more prolonged in high latitudes in the summer, and *vice versâ* in winter. †

C.—ACCLIMATISATION.

By acclimatisation here we mean the process by which the adult European officer and soldier becomes to some extent physiologically adapted to a climate different from that of the temperate climate of Europe.

The European soldier coming to India is nowadays suddenly translated from the United Kingdom (with an average annual temperature of 51°F.) to India (with an average annual temperature of 82° Fahr.); in India the sun's rays are for a large part of the year vertical, the rainfall violent and seasonal instead of being spread over the whole year, whilst the diurnal ranges of temperature may vary from 20 to even 60 degrees or more.

The Anglo-Saxon race has, it is believed, a greater power of adaptation to all climates than any other race.

* Lieut.-Col. G. M. GILES, I.M.S., *Climate and Health in Hot Countries*, pp. 5, 7.

† The influence of light on bacterial life is further referred to in the Sections on DISINFECTANTS and ELEMENTS OF GENERAL BACTERIOLOGY.

There is undoubtedly a distinct effort on the part of Nature to accommodate the human system to a new environment, and the amount of its successful effort in this direction represents the limit of possible acclimatisation. The means by which Nature brings about this adaptation is very complicated, and in general terms may be said to be a gradual adaptation of the body to a new distribution of the blood, together with a continuous pressure brought to bear upon the various physiological functions, dictating the necessity for the acquirement of general hygienic habits suited to the new state of affairs.

Physiological effects of the Indian climate on Europeans.—The altered conditions of life of the newly arrived European—change of air, food, clothing, etc.—the change of environment and the sudden translation from a temperate climate, induce a susceptibility to several of the diseases met with in this country. These put a demand on the economy in the way of adapting it to the altered conditions. This adjustment may in some respects be voluntary, but in others it is involuntary and beyond control. For instance, as regards involuntary adjustment, the effect of a tropical climate, whether dry or moist, on a European constitution is to gradually bring about a change in the customary physiological functions of certain organs of the body. Until this process of acclimatisation is fully attained and the system has accommodated itself to its surroundings, the individual is, from the slightest indiscretion, very susceptible to disorder and disease. The most important of these changes are a greater supply of blood to the surface of the body and a greater activity of the functions of the skin, which by profuse perspiration keeps the body at its ordinary temperature. The adjustment of the system to counterbalance the additional external heat is not completed for some time and until that time is reached, the temperature in the European is slightly higher than normal.* The body heat increases in the proportion of 0·05° F. for every 1° F. of the air. The average temperature of Europeans in Bengal is about 0·41° F higher than in England, and the average temperature of the native is about 0·5° F. higher than that of the European.

The blood distribution is modified, especially by its being to some extent transferred to the surface blood-vessels. This is chiefly at the expense of the blood in the lungs. The capacity of the lungs is thereby increased to the extent of 23 ounces. This extra space is taken by air ; the lungs do actually less work because the number of respirations per minute is lessened. The air is more rarefied in consequence of its higher temperature, and it therefore contains less oxygen, which fact alters the physiological working of the lungs. The result is that about 9 per cent. less oxygen is taken in, and about 20 per cent. less carbonic acid gas, and 20 per cent. less watery vapour, are discharged. This causes the retention of carbonaceous matter in the blood. At the same time there is

*Prof. W. J. SIMPSON, C.M.G., *Principles of Tropical Hygiene*, p. 12.

excessive activity on the part of the skin, liver, bowels and spleen. In general terms, however, the effects of the climate is to produce a decrease in the vital activities; the pulse is slowed, the heart's action slightly weakened, the powers of digestion enfeebled, the appetite decreased, the activity of the liver increased, and nutritive activity lowered. The abdominal organs become abnormally sensitive to external influences. The nervous system is at first stimulated, then slightly depressed, allowing it to be more readily affected by impressions from without. It is necessary to be on our guard against fits of irritability and fretfulness which are liable to be induced by the influence of the summer and autumn heat. This tendency should be controlled as it leads to great wear and tear of nerve force. Prolonged residence on the plains of India tends to produce two special effects, pallor and decreased muscular energy.

Exercise in the tropics raises the temperature more immediately and powerfully than it does in temperate climates, and if the temperature is taken after evening exercise (at a time when the normal diurnal physiological maximum is reached), it may show a difference of as much as 1·5° F., or more. The heightened temperature after exercise may be maintained for some hours. A march in the hot sun may raise the temperature several degrees, but this is as a rule due merely to the combined effects of exposure to the sun and fatigue, and although the fever thus produced may last a few days it passes off without any ill effects. This form of fever may have the specious characters of malarial or other specific fevers, but the absence of the more characteristic symptoms of such diseases shows its nature. The heat forming part of the heat-regulating mechanism is more easily stimulated in India than in temperate climates by such conditions as exposure to the sun, meals, and exercise. The effects of taking different classes of foods on temperature are, however, much the same as in temperate climates.

Exercise must be taken in India to ensure a healthy life. The tendency is for Europeans to take less and less as years of residence increase, and there is no doubt that the temptation to lead a more sedentary life grows increasingly. This, however, should be struggled against, and exercise short of fatigue regularly indulged in.

The entire process of acclimatisation is said to take about four years. It is during this time that diseases peculiar to the soldier in India are more liable to occur, but with moderate care he may keep in good health without suffering from any one of them, granted he was sound in every respect on his arrival in the country.

Complete acclimatisation of Europeans, or the power of residing in the country permanently for several consecutive generations, does not occur.

"Speaking generally the natives of tropical climates are not injuriously affected by the meteorological conditions of the climates they live in, any more than are the inhabitants of more temperate climates; their physiological activities are attuned by heredity and habit to the conditions they were born into. The European may be on his first coming to the tropics and until his machinery has adjusted itself to the altered meteorological circumstances, is liable to slight physiological irregularities, and this more especially if he persists in the dietetic habits appropriate to his native land. A predisposition to certain diseases and a tendency to degenerative changes may be brought about in this way, but acute disease, with active tissue change, is not so caused. In the tropics, as in temperate climates, in the European and in the native alike, nearly all disease is of specific origin. It is in their specific causes that the difference between the diseases of temperate climates and those of tropical climates principally lies.*

The scope of the present volume does not allow of one entering into all the details connected with the relations between the very varying climatic conditions of this country and all their effects upon the health of our troops in peace and war. Much that one has omitted is theoretical, for the relations of several factors associated with climate have not as yet been worked out. Sufficient has been said to indicate in a general way the effects of the climate of India on our European and Native troops.

On the plains November, December, January, February and March are as a rule the healthiest months as well as the coolest, and it is during them that men can work hard out of doors and keep very fit under such work. April, May, and June are as a rule very hot and dry, these are the months to avoid sunstroke. July, August, September (and often part of October) are the rainy season, during which anophelines breed freely and disseminate malaria; they are also the months in which dysentery, diarrhœa and liver complaints are most likely to occur

Although the Indian climate is warm, especially during several months of the year, one of the greatest dangers the European has to protect himself from is cold—he has not to withstand variations of 30 to 40 degrees in the day in his European home—hence a cotton garment worn during the heat of the day, may, if kept on until late in the evening when the temperature is many degrees lower, lead to a chill. Chills are acquired in India much more readily than in temperate and cold climates, partly because in Europe we wear suitable clothes, which we often neglect to do in India, and partly because the skin in India is unusually sensitive to variations of temperature which is not the case in Europe.

It is wise and conducive to comfort and personal fitness to use all means to bring the body into such a state of vigorous health as to render a very moderate amount of clothing sufficient to maintain

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*Sir Patrick Manson, *Tropical Diseases*, 4th Ed., p. xiv.

a proper degree of warmth in the body. One of the chief means of effecting this is by taking sufficient exercise in the open air, and avoidance of close heated rooms, and too warm beds at night. While individuals in health should endeavour to harden themselves, it is decidedly dangerous to be too lightly clad in winter.

Changes of temperature are often more injurious than sustained high temperature. Change from cold to heat may cause diarrhœa or other intestinal troubles; change from heat to cold is apt to produce catarrhs, both of the lungs and bowels, congestion of the liver, bring out latent malarial infection, etc.

Certain diseases and conditions are usually attributed to warm climates, such as the effects of solar heat, malaria, dysentery, cholera, plague, etc. The prevalence of these diseases is, however, dependent not so much on heat *per se*, but largely from the results of that heat—such as the determination of the vital activity of certain intermediate hosts and the extremely prolific development of the lower forms of vegetable life, such as bacteria.

The great majority of the diseases of the soldier arise from causes introduced into the body from without. These are all to a very large extent preventable. The methods of preventing these diseases are specially dealt with in PARTS II and IV.

Many diseases arise from bad habits and unhealthy modes of life. Amongst these we may include venereal diseases, unnecessary exposure to the sun, alcoholic intemperance, diseases of the alimentary tract from excessive eating, defective cooking, etc. Excesses in eating and drinking are matters for self-control, personal discipline, and abstemiousness. Heat apoplexy and heat exhaustion may be avoided by protecting the head and spine from the influence of the direct rays of a hot sun, suitable clothing, avoidance of unnecessary exposure, living a healthy life, etc. Venereal diseases may be controlled by the exercise of chastity, self-control, abundance of healthy exercise, etc.

The prevention of diseases introduced from without is more difficult as the agencies we wage war against are invisible.

A great deal is said and written about the influence of the Indian climate in the production of disease, but one is fairly convinced that climatic influence is often incriminated in place of faulty hygienic habits. The only condition that can be directly associated with climate is heat apoplexy and heat exhaustion. In a man living an unhealthy life the factor of climate will undoubtedly operate more unfavourably than one living a healthy existence.

It is scarcely conceivable that we shall ever be able to reduce our sickness-rate and mortality in India in either European or Native troops to what it is in our troops in the United Kingdom, but we can

approach this. Much can be done by judicious living to enable the individual accustomed to a temperate climate to live healthy in India.

We often hear people speak of the diseases of India in a way as if they embraced a vast field of their own, whereas there are probably not more than half a dozen of diseases that are peculiar to this country, most of the so-called indigenous diseases being met with throughout the tropical and sub-tropical globe. In the same way practically all the diseases that occur in temperate climates occur also in India, some of them with even greater intensity (small-pox), others about equal (tuberculosis), others with less intensity and prevalence (scarlet fever and diphtheria).

It is unfair, unscientific, illogical and unreasonable to attribute to the effects of climate the disturbances of the economy and disease that arise from insanitary conditions and unhygienic living. A century ago every illness from which the European suffered in this country was attributed to the climate, when as a matter of fact most of them were due to flagrant breaches of sanitary laws. In the early period of our occupation of India the death-rate was about 80 per 1,000 per annum among our troops. This has been so altered by the introduction of sanitary measures and attention to diet, water-supply, arrangement of exercise of the soldier and decreased alcoholism that the death-rate is now less than 8 per 1,000. Nor do we think that the potentialities for good of sanitary measures have reached their limit—there is still room for further reduction, and one is sanguine enough to believe that within the next ten years we shall find that our death-rate approximates that of the home army. It is only fair to assume that the difference that has taken place is due to sanitary measures and attention to personal hygiene. Apart from mal-hygienic habits and malaria there is little to make residence more unhealthy than at home, and with due attention to hygienic rules the European soldier from the time he arrives in the country may live to all intents and purposes as healthy as at home. On the other hand all authorities are agreed that to the European prolonged residence in India without change is injurious. The establishment of sanitoria for the hot weather in India for our European troops has robbed the climate of much of its terrors, a hot weather and part of the rainy season on the hills enabling men to remain thoroughly fit throughout the year.

Every one is agreed that prolonged exposure to high temperature of the Indian plains, whether dry or moist, does reduce vitality and lower stamina. Of the two dry heat is borne with greater comfort and is more healthy and less debilitating. There is now, however, no reason why any European officer or soldier should be subject to such continuous action of climatic heat and humidity.

There are three special precautions that the European has to take :—(1) Avoidance of unnecessary exposure to the sun and never

unless the head is properly protected by a helmet or sola topee; (2) avoidance of chills, which are easily acquired by exposure when the clothes are moistened by perspiration, and the body is heated and fatigued, in this precaution is specially included avoidance of abdominal chill; and (3) avoidance of malarial infection. It is absolutely necessary to avoid the inclination to lead a sedentary life, and avoid also the other extreme of a too fatiguing existence. Exercise should be regular and short of fatigue and the hottest hours of the day should be avoided for this. When heated or fatigued a cold bath should never be taken; a warm bath or a good rub down with a rough towel is then indicated.

The main measures of protection against infective disease at the present day are based on the teachings of hygiene and physiology, and consist of the adoption of all that is connected with leading a healthy life, the breathing of pure air, the drinking of wholesome water, use of proper food, strict attention to personal cleanliness, living amidst clean surroundings, the removal of human excreta in a proper manner as expeditiously as possible from our surroundings, similar removal of all forms of dry refuse, arrangements for the isolation and treatment of men suffering from infectious disease and the disinfection of the barracks, huts or tents they have occupied as well as of all clothing they have infected, and of all their discharges. The manner in which each of these individual factors affect health is dealt with later on under its own heading.

In an army in the field in Indian Frontier Warfare the chief factors favouring the origin and spread of the various diseases of field service are:—

(*a*) The resisting power of the men is lowered by fatigue, by scanty or indifferent food, and by exposure from insufficiency of shelter in varying conditions of climate.

(*b*) The men are massed together and are generally of an age susceptible to those diseases.

(*c*) Camping grounds may be fouled by the refuse and excreta of previous occupants containing possibly the germs of disease.

(*d*) The water-supply may itself be contaminated.

During peace times in cantonments there are various preventive measures in operation that either cannot be carried out in field service, or are so only under very exceptional conditions. In cantonments we have rigid sanitary rules, a good water-supply, a system of disposal of excreta by burial or incineration, and the food-supply is directly under control.

The application of the preventive measures now practised in military life in India calls for the co-operation of all ranks in the army. "This conception of organised sanitary effort is the fundanantal idea of any scheme of sanitation, and cannot be too strongly impressed on every one" (FIRTH.) Sanitation in military life is no longer a question with which the medical officer has exclusively to deal.

There is no better proof regarding the salutary effects of our present efforts to control disease amongst troops to be found than the fact that every year we have now widespread epidemics of cholera occurring in civil communities around cantonments, whilst our troops, European and Native, escape. There are numerous instances on record where in recent years cholera has prevailed in a severe epidemic form around Indian cantonments, whilst by a rigid system of sanitation, attention to all possible channels of infection, preventing all communication with the infected areas, etc., the disease has been excluded. It is now only very exceptionally that we are unable to prevent cholera entering cantonments. It is only a generation ago that cholera periodically invaded various cantonments and led to dreadful epidemics. The same is the case with plague in many stations in India – the civil community outside barracks has been decimated without its gaining a foothold in cantonments, and that without the employment of anti-plague inoculation. Similar remarks apply to small-pox.

Our troops are carefully chosen young men and youths who at the time of their enlistment are practically without any sign of disease. It is for us as far as practicable to render their surroundings healthy, and to teach them how to keep themselves healthy.

The laws of sanitation should be ingrafted into the soldier from his recruit days, so that he becomes as familiar with them as he does with his drill. It is not possible to make practical sanitarians of men by a few lectures given to them in cantonments. The hygiene of the soldier should be part of their routine teaching and work.

One recognises the fact that addresses such as these dealing technically with the health of the army in peace and war, do not solve the question of practical sanitation, and are defective in many respects, especially lacking in practical demonstration of many of the points adduced, and in many cases, wanting in detail. Under existing circumstances, however, they are the only means at our disposal.

D.—ADVANTAGES OF EDUCATION IN MILITARY HYGIENE.

A rudimentary acquaintance with practical sanitation saves many lives and a great deal of misery. We sometimes acquire infective diseases on account of the ignorance or carelessness of those with whom we live. Every person in the army should therefore have at least a general knowledge of the rules of health and practise them.

"No man can be a truly great general who is ignorant of the great laws upon which sanitary science is based. One of the greatest leaders of men was MOSES, and it is curious as well as instructive to read in Holy Writ the laws he enacted for the sanitation of his great camps. If we do not take care of the health of our men we shall never be able to bring them 'smiling to the post,' and unless they go into battle laughing with health and the good spirits which follow on good digestion, we must not expect great things from them" (Lord WOLSELEY.)

"As regards officers the possession of a knowledge of applied hygiene will afford one more qualifiction to command and supply one more agency of military effectiveness." * "Every individual soldier is an executive sanitarian and unless the officer and non-commissioned officer instruct their men in sanitary measures, the best efforts of the medical officer must go for naught." †

The sanitary service of the army in India is being gradually completed. Each Division has now its trained specialist in sanitation. Each Divisional Sanitary Officer has had the highest expert training that it is possible to obtain. This he gets at the Army Medical School, Millbank, London. He has also gone through a complete course of out-door practical sanitation with all that concerns the soldier's life in peace and war. He is a whole-time officer whose sole duty is connected with the practical application of hygiene to the requirements of the army. He is also a trained analyst and bacteriologist.

Theoretical and practical instruction in military sanitation is now being given in nearly all large station hospitals. The subjects dealt with are mainly those enumerated on pp. 29,30. The course usually consists of a dozen lectures and the same number of practical demonstrations. These are extended over a period of three weeks.

The practical demonstrations are conducted by visits of the instructing medical officer and the class to barrack rooms, cook-houses, ablution places, latrines, and urinals, water-supply stations or wells, incinerators, night-soil trenches, regimental institutes, coffee shops, canteens, aerated water factories, (dairies in which all the possible sources of milk contamination are pointed out and the methods of sterilisation shown and explained); regimental bazars, in which the state of the food and drinks sold is pointed out; the slaughter-houses are visited, live animals and carcases inspected, the way to dispose off offal pointed out; the bakeries investigated and bread-making explained, the dangers through dirty workmen indicated; the laundries are visited and their proper working pointed out; the duties of the mosquito brigade are demonstrated and dilated on, etc.

* Col. R. H. FIRTH, R.A.M.C., *Military Hygiene*, p. 1.
† Major R. BLACKHAM, R.A.M.C., *Military Sanitation*, p. 73.

At the present time we are making efforts throughout the army in India to educate British and Native officers and all non-commissioned officers in sanitary matters affecting the life of the soldier in peace and in sanitary discipline.

It is hoped that by the series of lectures and demonstrations that are being constantly given by medical officers to all branches of the service at the present day, education in preventive measures will rapidly spread, and that sympathy with and co-operation in sanitary organisation will soon become instinctive principles in the service.

Real and well grounded sanitary discipline regarding the prevention of disease is of paramount importance throughout the army. Sanitary discipline is as urgently necessary as fire discipline. There was less sickness, preventable disease, and inefficiency in the regular army than in the volunteer troops during the American-Spanish War of 1898, because the sanitary discipline was more rigidly observed in the former.

The company officer in the British service, the double company officer in the Indian army, and the section commanders in both, are the persons who are constantly with their men, and it is they who should become thoroughly familiar with the elementary rules of military sanitation and teach their men how to apply these rules.

Every officer also owes it to himself to scrutinse the sanitary condition of his personal surroundings, apart from any measures that may be taken by regimental or central sanitary authorities. If each person in a cantonment carried out the simple laws of hygiene, the problem of maintaining health would be much simplified.

One of the greatest effects of the South African campaign has been the official recognition of the fact that preventive medicine is a subject which concerns all branches and all ranks of the army; and the promulgation of Army Order 3 of 1908 is one of the most important changes that have occurred in the present generation.

In the home army it is now incumbent on all officers before promotion to the rank of Captain to pass an examination in elementary military hygiene and one would welcome its introduction into the Indian Army likewise. Intimately connected with the examination of junior officers in sanitation is the routine instruction of the rank and file in the rudiments of military hygiene, and the formation of a *cadre* for carrying out the details of practical sanitary work so far as prescribed. For this purpose it was essential to create a centre of instruction in military sanitation, a school of instruction was organised, opened, and conducted in Aldershot early in 1906 by Colonel R. H. FIRTH, R.A.M.C. Since then several thousand pupils have passed through the course of instruction including combatant officers and officers of the

R.A.M.C. and I.M.S., and the rank and file. The work is now conducted in a special building erected for the purpose in Aldershot, and the influence its passed candidates is having in the inculcation of the principles of hygiene in the army is to some extent being felt amongst our European troops in India. It is fully expected and earnestly to be desired that one or more similar centres for instruction in military sanitation will be established in India ere long, and that advantage will be taken of Colonel FIRTH'S presence in India in the organisation of such centres.

We as military medical officers can only advise you by lectures on hygiene as to what should be done; it is for you to carry out our advice and see that the men under you also do so. The medical officer might preach sanitary science without end, yet no advantage to the prevention of disease will accrue if his teachings are not put into practice by those whom he addresses.

Work of Military Medical Services in the History of Preventive Medicine.—"It was in the camps and barracks of the soldier, in field service and in tropical and unhealthy climates, that the lessons of disease prevention were first learned, and it may be truly said that the science of hygiene would not have attained the important position which it now holds in relation to the private and public life of the people, without the opportunities which the conditions of military life in all parts of the world afforded for studying the origin and spread of disease, and the efficiency of the measures taken to prevent it. In Germany, for example, it is freely acknowledged to-day that national military service has been the chief factor in raising the standard of sanitation throughout the country." *

It is to military medical officers that the world owes many of its greatest discoveries in connection with the infectious diseases of the tropics. To mention a few of these : it was Surgeon-Major R. T. LEWIS, A.M.S., who first discovered blood filariæ in man ; to Major RONALD ROSS, I.M.S., we owe our knowledge regarding the part played by mosquitoes in disseminating malaria ; to LAVERAN, a celebrated French Army Medical Officer, we owe the actual discovery of the malarial parasites of man ; to READ, CARROL and AGREMONTE of the U. S. Army we owe the discovery of the fact that the "tiger" mosquito (*Stegomyia calopus*) transmits yellow fever from man to man ; Colonel Sir DAVID BRUCE, R.A.M.C., discovered the germ that causes Malta fever (*Micrococcus melitensis*), and to officers of the Royal Army Medical Corps is due the discovery that goat's milk is the real source of Malta fever ; to Colonel Sir DAVID BRUCE is also due much of our knowledge of sleeping sickness or trypanosomiasis and the family of biting flies (*Glossina*) which transmit it from man to man ; from STRONG, FLEXNER and CLEGG of the

* *Journal of the Royal Army Medical Corps*, 1st January 1907, p. 104.

U.S. Army we have learnt much regarding the various forms of dysentery bacilli that infect man; to Brigade-Surgeon Lieut.-Col. VANDYKE CARTER, I.M.S., we owe our knowledge of relapsing or famine fever in India; to Colonel Sir W. B. LEISHMAN, R.A.M.C., Major DONOVAN, I.M.S., and Major LEONARD ROGERS, I.M.S., we are indebted for practically all we know about kala-azar; through Brigade-Surgeon Lieutenant-Colonel D. D. CUNNINGHAM, I.M.S., Colonel R. H. FIRTH, R.A.M.C., and Major S. P. JAMES, I.M.S., we ascertained the nature of oriental sore ("Delhi boil," Sind sore, etc.); various officers of the Indian Medical Service ascertained that plague is primarily an epizootic in rats and that man is only secondarily infected through the rat flea; and so on, one might enumerate various other important discoveries made by Military Medical Officers in all parts of the world. The above suffice to indicate the role that the Army Medical Officer of various countries has played in the progress of the world's knowledge of infective disease and the methods adopted in their prevention.

Pre-eminent examples amongst these is the discovery of the facts that have altered the whole science of disease prevention in the case of malarial fevers, yellow fever, Mediterranean fever, and sleeping sickness, filariasis, diseases which affect a large share of the human race.

Medical and sanitary officers in the field are executive officers in connection with all matters affecting the health of troops. Under our existing regulations, however, they have few executive powers. They may make recommendations which may or may not be carried out. One may here cite a few instances from one's personal experience in recent times which illustrate this. When acting as sanitary officer of a Division during the Agra Concentration of 1907, one repeatedly warned several Native regiments against the use of *musakhs* (goat-skins) for carrying water for troops. One made a sanitary inspection of the whole Division camps daily, and on three consecutive days found *bhistis* using *musakhs*. Finally, during a particular inspection nine *bhistis* of one regiment with *musakhs* were made prisoners. A young officer of the corps concerned was told to communicate the fact to the commanding officer of the corps with the request that the *bhistis* were to be punished regimentally for disobeying orders. The youthful officer quickly remarked "Well, sir, what are we to use, we have nothing else to carry water in." Orders against the use of *musakhs* had been issued to all corps in the Division as one of the sanitary precautions for general adoption. To quote another instance from the same source. Orders were promulgated that a man of each regiment was to see that the regimental latrine trenches only were to be used, and to be always on duty in the vicinity during daylight, that is, at a reasonable distance without harm to himself. One never went a round of the eleven regimental trenches in which there were not from three to seven of these men absent. A sweeper was also, by order, supposed to be constantly present, and in most visits from two to five of these functionaries were absent.

Personal hygiene to be taught to the soldier.—The time has come when we should teach every officer and soldier at least the elementary rules of general and personal hygiene. This teaching should be part of the routine duty of military medical officers. To give full effect to his teaching, the matter should be included in the regulations in the same way as other duties in military life are—an annual course of lectures on military hygiene to all ranks should be considered as important as the annual course of musketry.*

Synopsis of the teaching required.—One would therefore strongly advocate that a course of simple lectures on the rudiments of military hygiene and sanitation in peace and war be given by all medical officers of units to all ranks annually or twice a year in this country, and that this should be laid down in the regulations. This course should deal with the hygienic and sanitary considerations connected with such subjects as recruiting, physical development of recruits, marching, water-supplies, disposal of excreta; clothing, its composition and properties, washing of clothes, care of clothes and boots; bathing and personal cleanliness generally, nature and prevention of disease in general, and of the special diseases to which soldiers are liable in peace and war; rules for maintaining health and the reasons for them; food and food-supplies and their qualities, methods of cooking, etc. The number of these subjects could be greatly increased, and yet be within the scope of the soldier's requirements. What we specially wish to do is to tell soldiers, in easy language, how to keep well, how to prevent disease, and to give them simple reasons for the lessons we impart. A thorough grounding in the principles of elementary hygiene is given to all combatant officers and men of the Japanese army, while the exact execution of all hygienic measures adopted in field service is guaranteed by the strict discipline, and the natural desire of cleanliness inherent in the Japanese soldier.

We have scientific reasons for all modern preventive measures.—We have scientific reasons for believing that the preventive measures we are now employing in the army are based on a sound principle—the principle of cause and effect. In numerous ways we have advantages that our predecessors of 40 years ago did not possess. To illustrate the soundness of present-day hygienic measures, let us take a few examples from the commonest diseases that affect our Frontier Armies in the field.

Malarial fevers, their nature and prophylaxis.—We now know definitely that *malarial fevers* are due to a class of protozoon invading the red blood cells, destroying a large number of these cells during each attack of fever, and invading certain organs of the body; that the products of these parasites give rise to the pathological and clinical

* This remark was made by me in a lecture in July 1906. In January 1907, regulations were published prescribing a course of lectures on hygiene to all ranks in the Home Service.

sequence met with in all malarial fevers lasting any length of time, that this protozoon is introduced into the human blood by certain species of anopheline mosquitoes, that these mosquitoes acquire their infectivity from the blood of persons already the victims of malarial infection; and, lastly, that quinine has the power of preventing the further development in the blood of the spores set free from the red blood cells during the first part of each attack of fever, and that if given before a sufficient number of parasites are in the blood to create fever, quinine will, in the vast majority of cases, prevent such fever altogether.

The task of preventing malarial fevers generally is great, because when carried out in its integrity it has to deal with (1) the exclusion of infected persons from the healthy; (2) exclusion of adult *anophelines* from infected persons; (3) the administration of quinine prophylactically to all persons who have been attacked by infected anophelines; (4) the destruction of the ova and larvæ of these anophelines in their breeding places, and (5) protection of healthy persons from adult anophelines generally. These processes are being carried out more or less in their entirety, and will bear fruit in future campaigns in malarious districts in which, as far as practicable, they will be continued. The Japanese, at one period during the late war, used hand and head mosquito-netting to protect themselves from mosquitoes; mosquito-proof wire-gauze verandahs, doors, and even inner rooms, are now largely used in the West Coast of Africa, and on some railways in Italy, and all these measures are being adopted for the protection of workmen in the construction of the Panama Canal.

Dysentery, its causes and prevention.—Regarding *dysentery*, we now know it to be of two chief kinds, according to its essential cause; *amœbic*, due to a lowly-organised protozoon, and *bacillary*, due to one of several varieties of bacilli of what are known as the colon group or type, this form of dysentery being much more common than the *amœbic*. These bacilli invade the large bowel, and are wide-spread in soil and water contaminated in any way by excreta of infected persons; usually they produce no evil consequence in the healthy bowel, because the functionally active cells lining the mucous membrane resist invasion by these bacilli; when, however, these cells become damaged by, say, the irritation of imperfectly cooked food, food of an improper kind, over-eating when fatigued or when suffering from a chill, or from any cause of indigestion, these bacilli set up a process of acute catarrhal inflammation of the large bowel, such as is met with in the dysentery of field service. We know that the excreta of these cases are capable of rapidly spreading the disease to others. This teaches us the necessity of careful attention to the quality of the food, its proper cooking, the avoidance of chill and all causes of indigestion; the destruction by incineration, if possible, or by reliable liquid disinfectants of the fæces of dysentery cases, the need of isolating these

patients, and sending them down to the base or to special field hospitals, and away from the general force.

Typhoid fever, its essential cause and means of prevention.—Regarding *typhoid fever*, we know it to be due to a particular kind of bacillus, that this gains access to the bowel chiefly through specific contamination of water and milk, or the products of milk or through other food; that the fæces and urine of these cases contain the bacillus for some time after the patients recover; that soil on or into which these excreta are cast may retain the bacillus in a virulent state for many weeks; that the dried and pulverised excreta from the soil, or floors of huts or tents, may be blown about by winds and swallowed, and that flies carry the infection from various sources; we also know that by boiling water and milk this bacillus is killed, and that it cannot pass through a Berkefeld or a Pasteur-Chamberland filter. The lessons from these facts are obvious, especially those of (1) isolating the patient, (2) incinerating both fæces and urine by fire or destroying their infectivity by such powerful agents as solution of corrosive sublimate, or other potent disinfectant, scrupulously careful attention to water-supplies, and food, and to latrine trenches, elimination of flies from camp, etc.

Somewhat similar statements might be made with regard to many other diseases, such as cholera, infective diarrhœa, etc., met with in India.

Scientific medical work in India.—An enormous amount of classical work has been, and is being done, in connection with all these and other diseases, the ultimate practical object of which is to place our preventive and curative methods on a sounder basis. For example, solid scientific bacteriological and biological work is being carried out in India at the present day at the Lister Institute of Bombay, King Institute of Madras, the Central Research Institute in Kasauli and with their selected staffs of trained bacteriologists are constantly, quietly and noiselessly, adding to our knowledge of tropical disease and methods of prevention. The annual reports, special papers and literature generally, emanating from these institutions, indicate that the general trend of work is towards elucidation of causes, and the establishment of preventive methods on sounder bases. The annual reports of our Command Sanitary Officers show that no outbreak of preventable disease escapes investigation, and that an endeavour to perfect our present measures of prevention is their watchword.

E.—Statistics of Disease in Peace and War.

All works on military hygiene should deal with at least part of the past history of disease in armies, the causes that gave rise to them, and the effects that have accrued from measures adopted to keep them in check. Without such items in the history of military hygiene we are liable to lose sight of the dangers that always exist, and perhaps not be prepared for them when they arrive. It may therefore be

instructive for us to briefly review the extent to which disease has been responsible for loss from inefficiency in armies in the past and to contrast it with our present-day medical statistics.

The statistics of all the first class armies of modern times show that both sickness-rate and mortality are undergoing progressive decrease. That reduction is largely due to the adoption of the teachings of sanitary science.

Progressively reduced sickness and mortality.—There has during the last 100 years been a progressive reduction in the sickness and mortality in not only our only army, but in that of all civilised nations. During the first half of the last century the annual death-rate of our European troops in India was about 70 per 1,000; during the last ten years it has been less than 10 per 1,000.

The following table* shows the amount of sickness and mortality among our European soldiers in India in the first half of the last century:—

Garrison.	Period.	Annual Ratio per 1,000 of Strength.		Period.	Annual Ratio per 1,000 of Strength.	
		Admitted as sick.	Died.		Admitted as sick.	Died.
Bengal	1817—1836	1,577	75·6	1838—1856	2,047	76·2
Madras	,,	1,783	76·1	,,	1,741	41·5
Bombay	,,	1,451	62·8	,,	2,117	60·9

The sickness-rate and mortality were during these periods at home also very high. Contrasted with the periods given in the foregoing table is the one of the European army in India for the years 1859 and 1906.

	Per 1,000 of Strength.							
	Admissions for sickness.		Deaths.		Invalided for sickness.		Constantly non-effective	
	1859.	1906.	1859.	1906.	1859.	1906.	1859.	1906.
India	1,814	833·6	322	10·38	11	8·84	68	52·41

About the year 1858 at home the mortality of soldiers was about $2\frac{1}{2}$ times greater than that of agricultural labourers, and about twice that of in-door labourers. The subject as to the causes of this preponderance of disease and mortality in military life was investigated, and these causes to some extent ascertained and strenuous efforts made to remove them. The great cause was found to be consumption from overcrowding and defective ventilation, while other diseases arose from defective feeding, improper clothing, etc.

In the German Army the admissions per 1,000 in 1868 was 1,496; in 1905, it was 605, the death-rate in 1868 was 6·9, in 1907 it was 1·9. In the French Army the admission rate in 1885 was 1,130, in 1905 it was 660; the death-rate was 7·8 in 1885

*From Col. R. H. Firth's *Military Hygiene*, p. 6.

and 1905 it was 3·11. For the same years in the United States Army the admission rates were 1,402 and 1,250, and the death-rates 7·3 and 6·1. The admission rate of the Russian Army in Europe in 1905 was 325 per 1,000 and the death-rate 3·2. In the Austro-Hungarian Army in 1905 the admission rate was 636 per 1,000 and the death-rate 2·2.

In 1860 in the British Army in India there were over 1,500 admissions and nearly 1 000 deaths from *cholera*. In 1867, 529 men died of cholera. In the 10 years 1897—1906 only 310 men died of this disease. "In 1869 the army in India lost from cholera alone nearly three times as heavily as it lost in 1906 from all causes combined. In 1869, different regiments lost one-sixth, one-fourth and even one-third their numbers in a few weeks from cholera." Twenty years ago we had cholera every year at certain seasons in many stations, frequently in the form of explosive epidemics due to specific contamination of water-supplies.

In 1860 we lost by death and invaliding from tuberculosis 1,143 men. In 1906, with an army of 230,000 strong, we lost only 590 men, a reduction of nearly 60 per cent.*

Fifty years ago the death-rate from consumption in the Guards at home was three times greater than that of the civil population; now it is less. At that time 10 men out of every regiment died annually of consumption, now the average is about 2. In India the consumption death-rate is now about 1·8 per 1,000.

The great reduction of tuberculosis in the army is due to improved ventilation, the absence of overcrowding, and the immediate isolation and invaliding of all cases of tuberculosis. "This policy (of invaliding) reduces to a minimum the opportunities afforded for the spread of tubercular infection among soldiers. Its practical efficacy can only be secured by the co-operation of regimental officers in preventing overcrowding in barracks, and the maintenance of cleanly habits among the men, notably, the strict suppression of spitting."

The general health of both Native and European troops has improved throughout the country, and there are solid grounds for believing that this improvement will continue. We have by no means reached the obtainable limits of sickness and mortality yet. There are still many directions in which improvements may be effected.

In *peace times* the *chief diseases* of our *European troops* in India at present are—venereal diseases, malarial fevers, typhoid fever, diarrhœa and dysentery, heart affections, rheumatism and local injuries. The *chief causes of death* are—typhoid fever, pneumonia and abscess of the liver.

The *chief causes of invaliding* from the service in European troops are various affections of the heart, and at some distance, tuberculosis, diseases of the lungs, debility and diseases of the nervous system.

Service of European troops in India does not increase permanent invaliding, because the men are carefully chosen, and a large number are now sent home for change. There are about 25 per 10,000 invalided annually of whom only 9 per 10,000 are permanently invalided.

**Journal of the Royal Army Medical Corps*, July 1908, p. 66.

The *chief diseases in the Native army* in peace times are—malaria, dysentery, diseases of the lungs, enteric fever, unknown fevers, digestive troubles, venereal diseases, rheumatism and local injuries. The *chief causes of death* are—pneumonia, cholera, malaria, enteric fever, and tubercle of the lungs.

The total number of men invalided from the Native Army in 1908 was 842 as compared with 728 in 1907, mainly for tubercle of the lungs, injuries, debility and malaria. That malaria is still the dominant cause of inefficiency is shown by the fact that in the Native Army in 1908 there were 33,438 cases. One regiment had as many as 2,227 admissions per 1,000 of strength, and in several stations the average showed that every man was admitted during the year for malaria.

The special *diseases in Indian Frontier Warfare are*—malaria, dysentery, infective diarrhœa, typhoid fever, diseases of the lungs, specially pneumonia and bronchitis, and cholera. These are also the chief causes of mortality.

In Indian Frontier Warfare there is often a six-fold increase of dysentery, infective diarrhœa and typhoid fever, as compared with the peace time incidence; malaria is usually increased by 20 per cent; diseases of the lungs and digestive system rise, whilst venereal disease drops.

Comparing the British Army with foreign armies at the present day, the *admissions* into hospital from all causes per 1,000 of strength are—United States, 1,250 admissions; French, German and Austrian, above 600; British Army at home, 448, in India, 717; Russian, 325. This is, of course, largely affected by the regulations regarding the treatment of patients by allowing them to attend hospital instead of admitting them.

The *death-rate* per 1,000 in the United States Army is 6·14; British Army and French Army, 3·07; German Army, 1·9; Russian Army, 3·2, which is high compared with the admission rate, and therefore points to a large number of men being "detained" or treated out of hospital.

Venereal disease in other armies:—United States, 179 per 1,000; French, 67; Austro-Hungary, 62; Russian, 45; German, only 20; our own army, at home 82, and in India, 115. The British Army and the United States Army are the only armies in which some form of regulations are not in force for preventing the spread of venereal diseases.

Enteric fever is common in the French Army in which there is an average of 14·1 per 1,000 of strength; we have about 15·6 per 1,000 in our European troops in India; Russian Army, 3·8; United States, 3·57. In our European troops at home there is a lower enteric fever rate than in any other European Army.

Tuberculosis in different armies:—French, 5·3 per 1,000 of strength; United States, 4·7; British Army (at home) and Russia, 2·5; German and Austro-Hungary, 1·25. Disease of the heart is much more common in the British Army than any other army in Europe, occurring to the extent of 7·3 per 1,000 as contrasted with United States, 3·8; German, 3·5; French and Russian, 2·5; and Austro-Hungary, 1·9.

The branches of the service to which men belong and the stations they are quartered in, affect the extent to which men are rendered inefficient by disease; in cavalry it is highest, then infantry, lastly artillery; the technical corps are the healthiest, possibly because of their higher status, higher class, better education and better pay.

Statistics show that the mortality of troops at home is now less than it is in civil life, and in both European and Native troops in India it is considerably less than that of the natives of the country.

The most important military medical statistics are :—The admission from disease, the death-rate, rate of permanent invaliding, and the number constantly sick. These must be taken collectively to be of real value. The admission rate is not reliable, nor is the number constantly sick, which depends on the latter, and both these are regulated by the rigidity with which the regulations are carried out as regards admitting men who are really ill. The death-rate is greatly reduced by removal of men likely to die by invaliding (as in the case of tuberculosis). A high invaliding rate often means a low death-rate. The fairest index of comparative non-effectiveness is probably represented by the losses by death and invaliding.

There is a distinct difference between the causes of disease and mortality, and the factors that bring those causes into operation, in times of peace and during warfare.

It is not to be expected that a force in the field, whether in tents, billets or bivouac, will remain as healthy as in cantonments. "The inevitable physical and mental stress, the fatigues of marching, insufficient and irregular meals, scanty and often bad water, and a number of breaches of rules of personal hygiene that are inseparable from campaigning, must tend to lower the general health and the resisting power of the men."

There have been many instances in which the same nation has sent expeditions at different periods over the same ground with vastly different results as regards sickness-rate and mortality from disease. In our own army we have had the terrible Ashanti Expedition of 1854 as contrasted with the excellently organised expedition of 1873-74. In the former all the force melted away, all that did not die were invalided. In 1873 the death-rate was 1·7 per 1,000. Again our Walcheren campaign as compared with other campaigns in Holland. The terrible record of sickness and death in the Crimea in 1854, as compared with the marvellous change for the better in the winter of 1855-56. The Russian campaign in Turkey in 1828 as compared with that of 1878. The Russian army of 100,000 strong that invaded Turkey in 1828 returned to Russia two years later with only 15,000 of their original number. The vast majority of the 85,000 were the victims of disease that followed them over the Balkans into Turkey and back again.

The history of the past shows that there has been an enormous waste to field armies from sickness and death due to preventable causes.

In the Walcheren Expedition of 1809 the deaths from disease were 347 per 1,000, whilst the entire force was non-effective from disease.

In the Peninsular War, three times as many men were lost by disease as from the wounds of the enemy, and all the force passed through the hospitals twice from disease.

In the Tirah Expedition of 1897-98 there were 25 admissions for disease for one due to injuries inflicted by the enemy, and 14 deaths from infective disease to each death from war injuries.

Napoleon lost 40,000 men round Paris from typhus fever after his return from Moscow.

In 1870, the French lost 23,000 men from small-pox whilst the Germans, exposed to the same infection but were efficiently re-vaccinated, lost only 200.

In South Africa during the three years the war lasted, typhoid fever accounted for one-tenth of the admissions into hospital, dysentery one-fourteenth, therefore both these diseases together about one-sixth; they caused two-thirds of the total deaths from disease, and one-half of the total deaths from all causes. Dysentery alone accounted for 31,000 admissions.

In the American-Spanish war of 1898 disease decimated the American army before they even sailed for Cuba.

Disease much more frequent than wounds in war.—The medical histories of all our frontier wars tell us that the invaliding rate and mortality from disease have always been greatly in excess of those due to injuries and wounds inflicted by the enemy. This was markedly the case in the third, fourth and fifth Burmah wars, in Tirah, Afghanistan, Bhotan, and even comparatively recently, in Thibet. In large expeditions in which a mixed force of the Indian Army takes part, in general terms malarial fevers, dysentery, diarrhœa, enteric fever, and pulmonary affections (especially pneumonia and bronchitis) are the predominating causes of deaths and inefficiency from sickness. These statements are fully borne out by the tables given in the Appendix abstracted from the medical histories of the campaigns and expeditions to which they refer.

Inefficiency from disease as compared with that due to injuries inflicted by the enemy.—In all modern wars, except the Franco-German and the late Russo-Japanese war, the proportion of sick to the force has been very considerable, and the deaths due to disease have been greatly in excess of those due to injuries inflicted by the enemy. In the South African war there were about 7,000 deaths from wounds and accidents, and about 14,800 from diseases, and in the same war we had about 450,000 admissions from disease, and of these about 63,000 were invalided home. The Japanese in the recent war had 47, 367 killed whilst only 17,533 died from disease.

American Army in Cuba during 1898.—In Cuba in 1898 in the United States Army only 347 soldiers died from actual wounds, 2,565 died from disease; and defective medical and sanitary arrangements are said to be responsible for a certain proportion of these latter. There has been a curious coincidence in the experience of the United States Army in the Philippines and in our own European troops during most of our former frontier wars—malarial fevers, dysentery and enteric fever being the maladies chiefly suffered from in both cases.

French in Madagascar in 1894.—The French in their Madagascar campaign suffered terribly from disease—especially malarial fevers, dysentery, enteric fever and ophthalmia, " climatic exposure and deprivations finally giving rise to heart-

rending sickness and mortality." Of about 15,000 men, 6,000 are said to have died from climatic effects, and only 21 from wounds. Not one man escaped malarial fever of one kind or another, and in some of the transport ships with men returning to France, between 90 and 100 men died on the voyage.

For further statistics *vide* **Appendix**.—For further statistics showing the great disproportion between cases of sickness and those of injuries inflicted by the enemy, one would refer to the figures contained in the medical histories of our Indian frontier campaigns,—some of the more recent ones are given in the APPENDIX.

The following comprehensive table * shows at a glance that the degree of disease incidence, as well as the amount of losses sustained from acts of the enemy, has varied immensely. "This is not to be wondered at, considering the diversity of conditions under which these little wars or expeditions have been conducted. The most striking feature of these statistics is the marked excess of the sickness-admission rates over those for injuries received in action. Roughly it may be said, that for each man admitted to hospital for some wound or injury, there are

Expedition or war.	RATIOS PER 1,000 OF STRENGTH.					
	Admission.			*Deaths.*		
	For disease.	For wounds or injuries in action.	Total.	From disease.	From wounds or injuries in action.	Total.
Ashanti, 1873-74 ...	474·0	70·0	544·4	16·00	6·0	22·00
Perak, 1875-76 ...	227·0	1·6	228·6	20·00	1·6	21·60
Zululand, 1879-80 ...	739·0	12·0	751·0	24·83	1·8	26·63
Afghanistan, 1879-80 ...	869·9	51·0	920·0	36·03	6·92	42·95
Egypt, 1882 ...	554·0	29·0	583·0	6·06	7·15	13·21
Sudan, 1884 ...	76·2	49·2	125·4	...	31·36	31·36
Nile, 1884-85 ...	808·6	22·4	831·0	40·01	11·70	51·71
Suakim, 1885 ...	282·9	13·7	296·6	7·87	6·50	14·37
Sudan, 1885-86 ...	1100·3	46·9	1147·2	29·44	9·82	39·26
Nile, 1889 ...	73·5	3·3	76·8	1·31	0·65	1·96
Ashanti, 1895-96 ...	49·27	...	49·27	0·56	...	0·56
Chitral, 1895 ...	1530·00	14·0	1544·00	49·39	5·10	54·49
Dongola, 1896 ...	976·60	...	976·60	81·70	...	81·70
Bechuanaland, 1896 ...	531·00	11·0	542·00	28·60	2·6	31·20
Mashonaland, 1896 ...	782·00	53·0	835·0	3·80	15·0	18·80
Tirah, 1897-98 ...	573·8	25·6	599·4	28·24	2·67	30·91
Nile, 1898 ...	1101·7	56·7	1,058·4	36·18	15·67	51·85
China, 1900-01 ...	1051·7	10·2	1,061·9	22·71	2·35	25·06
South Africa, 1899-01 ...	746·0	34·0	780·0	69·00	42·00	111·06

25 admitted for some form of disease. The disparity is less marked in the corresponding death-rates, but even there it is quite the exception for the death-rates from action effects to be in excess of those from

* From Col. R. H. FIRTH'S *Military Hygiene*, p. 25.

disease. The usual ratio is 5 deaths from disease for one from wounds or injury." The disease incidence and death-rate vary considerably, because of the varying conditions of campaigns. The one characteristic of all is the high admission-rate for sickness as compared with that from injuries inflicted by the enemy.

Campaigns have more than once been entirely abandoned, because of the amount of sickness at the bases. Surrenders have at times been enforced by reason of the amount of disease amongst the besieged in forts and garrisons.

The special causes of disease in war are climatic exposure, pollution of water, soil and air, and indifferent food. Preventable diseases invariably play a very important part in the sickness-rate of Indian frontier campaigns. The diseases chiefly met with are due to microbes (*protozoal* or *bacterial*) which are disseminated by water, air, dust, food, flies and mosquitoes.

Opinions regarding the comparative absence of disease in Japanese in the late war.—Some writers have given us unofficial accounts of the results of medical and preventive measures adopted by the Japanese during the late war which are mostly second-hand. Some of these are highly coloured, optimistic comparisons with the results obtained by other powers during campaigns; others consider that most of the accounts published are exaggerations. There are, however, many official and reliable accounts of Japanese Medical Organisation in the field, as well as various works dealing with the war. We may quote from a few of these. In *The Siege and Fall of Port Arthur*, p. 268, MR. RICHARD SMITH tells us that " the casualties of fighting during the siege amounted to 65,000, the number put out of action by sickness ran to nearly 25,000 more. The proportion of sick to wounded is phenomenally low. In no previous war were the methods for killing and wounding so fertile—including the use of the large 11-inch howitzers and the siege trains, the full use of dynamite for explosions, and the annihilating hand grenades." He speaks highly of the skill of the Japanese Surgeon and the fine modern equipment of their hospitals. " It is possible that the insanitary state of the hospitals in rear of the lines at the front may not have had the same deadly effect similar conditions would certainly have had upon the wounded in any Western Army." "The hospitals themselves were clean and good, but the surroundings were insanitary." He tells us that the Japanese bear pain wonderfully, that little anæsthesia was adopted, even in large and long operations.

Explanations given as to exemption of Japanese from disease unfounded.—It has been repeatedly stated by writers that there is something racial or national in the comparative absence of typhoid and other camp diseases in the army around Port Arthur. This is extremely doubtful. The Russians inside Port Arthur appear to have suffered severely from virulent typhoid, but this can be explained without resorting to the sweeping theory of national exemption on the part of the Japanese. It will be seen later on, that the Japanese did suffer from both enteric fever and dysentery, and that with the exception of beri-beri, these were their chief diseases. One other point in favour of Japanese is, that they have a wonderful control over their thirst, and all the soldiers wisely avoided any water over which a notice that it was unfit for drinking was placed.

Major Seaman's (U. S. A.) opinion.—Many things point to the fact that the Japanese were conscious that the greatest harm to large armies in long campaigns is preventable disease, and they made great efforts to neutralise this enemy. Major SEAMAN, U. S. A., on interrogating a distinguished Japanese officer during the campaign on this subject received this reply : "Yes, we are prepared for this (preventable disease). Russia may be able to place 2,000,000 in the field; we can supply

500,000. You know in every war, four men die of disease for every one who falls from bullets. That will be the position of Russia in this war. We propose to eliminate disease as a factor. Every man who dies in our army must fall in the field of battle—in this way we shall neutralise the superiority of Russian numbers, and stand on a comparatively equal footing."

"Up to August 1904—9,862 cases had been received in the Japanese Hospital at Hiroshima, of whom 6,636 were wounded. Of the entire number up to that time only 34 had died. The loss from preventable disease in the past six months was estimated at one per cent., this in what was considered an unhealthy country." Compare this with the losses of the British in Burmah during the 3rd, 4th and 5th wars, in Tirah, Somaliland, and with the American losses during the Spanish-American war in Cuba, and even worse, in the Philippines. In Cuba the mortality from wounds was 347, from disease 2,563—that is, about 7 to 1—one per cent. in the Japanese as compared with 35 per cent.

"Probably there never was such a clean army as this in the history of the world. It is possible to march on a hot day in the middle of a battalion without any offence to the most delicate nostrils. We, I am told, are by no means equally inoffensive to the Japanese. However cleanly we may be, our habit of devouring great quantities of meat gives us a carnivorous aroma, which is not at all to their taste. It is dreadful even to suspect that when we think ourselves most fascinating, we may only succeed in reminding our pretty Geisha friends, of a zoological garden on a hot afternoon." *

High state of perfection of Medical Organisation of Japanese.—All accessible records point to the fact that in the Japanese Army the medical organisation is considered very important, and that preventive measures against disease, take a foremost position. So much so is this the case, that their men have been stated to be pampered and "coddled," and that all ranks are dominated by doctor's orders. Nevertheless the decidedly beneficial effects of those orders appear to have been all that could be desired in the reduction of preventable disease. The doctors have acquired universal confidence in the army by reason of their undomitable pluck, solid earnestness in their work, untiring energy, unswerving devotion to duty, enthusiasm as regards the care of the sick and the prevention of disease, in which connection their instructions are always implicitly obeyed by all ranks.

Hardiness of the Japanese Soldier.—The Japanese had shown their hardiness before the late war. Though unaccustomed to the rigours of a severe winter, the Japanese soldiers in 1894-5 bivouacked on ground frozen and covered with snow; they marched in the face of driving winds and blizzards for miles and miles over rough stony ground, slippery with ice or frozen sleet, or snow, starting at 2 or 3 A.M., daily, and frequently not ending their march until late at night, the thermometer constantly below zero. Some of them even marched under such conditions with frost bitten feet, their worn out shoes offering no protection.

The terrible ravages from scurvy amongst the Russians in Port Arthur.—At the capitulation of Port Arthur, the Russians had in their hospitals there about 17,000 men, of these only 3,389 were wounded, the others suffering from various diseases. The most common was scurvy, of which there were 5,625 serious cases under treatment, but besides these about 90 per cent. of the men in the hospital were suffering from slighter attacks of the disease, which was also spreading rapidly amongst the men in the forts and trenches. Ten days before the capitulation there were about 100 fresh cases daily, but the number increased rapidly to 200, 400, 800 and 1,000 on the last days—it is stated that in a few days the whole garrison would have succumbed to it. The state of the hospitals at this time was very bad, they were overcrowded, and the fresh sick steadily increased. The bandages and compresses had given out, compresses were improvised from seaweed washed in solution of potash; there was no edible food for the sick and wounded, lack of fresh fruit and vegetables was keenly felt; bread and horse-flesh alone were used as food—poor fare for sick men. Our own experience of this disease in the Crimea is well known.

**A Staff Officer's Scrap Book*, Vol. I., by SIR IAN HAMILTON.

PART I.

PHYSICAL TRAINING AND DEVELOPMENT OF THE SOLDIER.

A.—Recruiting and Physical Training.

Examination of Recruits.—Efficient recruitment being the prime necessity in the organisation of a military force, the intelligence and faithfulness with which this duty is performed constitnte important elements upon which the future health, efficiency, and mobility of an Army depend.

Instructions for the examination of recruits and non-combatants are laid down in I. A. F., K. 1160, and should be carefully studied by all junior medical officers. The medical examination of reservists is considerably slacker than that for initial enlistment, being limited to finding out whether they are fit for further duty according to their age, class and length of service; they are not to be rejected on account of the smaller disabilities.

All parts of the examination of candidates for the Army as laid down in the Regulations must be rigidly adhered to. This examination when carried out to the letter is a very severe one. Our rejections for the Indian Army is high, but if the standard required is to be maintained, there should be no relaxation.

The periods for which men enlist vary with the different branches of the service and are laid down in the regulations. Recruits of European troops are taken between 18 and 25 years, except in some sections of the technical corps in which the age is extended to 30 or35 years. Boys are enlisted as drummers and for bands. Recruits for the Native Army are to be between 16 and 25 years of age, except discharged men seeking re-enlistment and men for technical branches. The height of cavalry recruits is left to the commanding officers. The minimum height for Gurkhas is 5 feet, for other infantry regiments 5 feet 4 inches. Special standards of height and chest mea urements are not allowed.

From a physiological standpoint the recruit should not be enlisted until 21 years of age; the age of 18 is too young—the bones are not properly developed until 25 years of age, the heart is still growing rapidly and any serious strain may affect it. Therefore most of our

recruit lads are undeveloped. The degree of development, however, varies from a state of high physique (which is exceptional) to one of very incomplete development (which is common). The youngest soldiers are those who break down most readily both in peace and war.

The medical officer satisfies himself that the vision is up to the prescribed standard as tested by the test-dots card, that the height and chest measurement are also up to standard (A. R. I., Vols. II, V, VI); that his speech and hearing are normal, that he is healthy, strong, active, sufficiently intelligent, possesses free movement in all the joints, his physical development is good, is free from disease of the nervous, circulatory, respiratory, digestive, cutaneous, lymphatic, generative and secretary systems. Special care is to be given to tracing the presence of contagious or infectious diseases, rupture, dysentery, severe malarial disease and kala-azar; there should be no evidence of previous attacks of convulsions, old injuries of the head, or of a personal or family medical history which would be likely to render him unfit; and that his age as recorded is borne out by his appearance and development.

In all examinations the recruit should be stripped as far as privacy and decency allow. In the case of recruits examined at head-quarters of a unit, the medical officer is responsible for the correct entry of the age, height, and chest measurement; at recruiting depôts the recruiting staff officer is responsible for these.

When taking the chest measurement the measuring tape should be applied evenly but not tightly, its upper edge touching the lower border of the shoulder blades behind, and its lower edge passing just above the nipples, the arms hanging at the sides. The minimum chest measurement is recorded after the recruit has counted from 1 to 10 slowly without drawing a breath, and the maximum after the chest has been fully expanded; supposing the former measurement is 32″ and the latter 34″, this is recorded as $\frac{32}{34}$″.

The chest measurements of artillery recruits of 5 feet 6 inches and upwards should be—16 to 17 years of age, 32″; 17 to 19, 32½″; 19 to 22, 33″; 22 to 24, 33½″; 24 to 25, 34″. The minimum chest measurement for Gurkhas of 5 feet is 32 inches; otherwise for this class no measurement is laid down.

The girth of a well-made man's chest should be more than one inch over half his height. Width of shoulder is another important factor—it should not be less than two-ninths the height. No recruit should be enlisted who fails to fulfil the conditions of chest measurement and chest expansion laid down in the Regulations.

'The vital resistance of an individual is closely related to the symmetrical development of all parts of the body." It is important that there should be a proper relation between the height, weight and chest measurement in forming an opinion as to the physique, and of these relations good weight for height is the first requirement. "An

easy rule (for European troops) is that up to 5′ 7″ twice the height in inches ought to be about the weight in pounds, adding 7 pounds for every inch above 67 inches."

It is generally accepted that, as a rule, tall men do not stand the hardships of a long campaign so well as men of medium stature, and unless in tall men there is a symmetrical general development, they should not be accepted on account of height alone.

The question of the absolute weight of Native recruits should not be pushed too far, as many lads of big bone, who have been on a low diet in their village homes, rapidly fill out and develop. A thin lad may appear undesirable, but if he is sound in wind and limb and has the required chest measurement, one would be inclined always to give him the benefit of the doubt. The question of rejection or acceptance on the score of weight should be left to the judgment of the recruiting medical officer.

The capacity of the chest is important in estimating the fitness of a recruit. The heart and lungs, which represent the staying power of a soldier, are of great significance. Mobility of the chest is in this respect an important point to record, especially with reference to the height and weight. Free mobility is usually associated with the other main quality in the lungs—good capacity.

The expansion range (the difference in the girth between a fully expanded and an empty chest) for European troops is two inches.

Those who have previously followed sedentary trades and occupations gain weight rapidly, those who have led an easy life with full feeding lose it. Weedy lads brought up in poverty, and those who have lived under conditions of malhygiene, rapidly thrive on the soldier's fare and life.

If we except tuberculosis, hereditary diseases or defects of body are practically not met with in the Army, as the careful examination to which candidates for enlistment are put eliminates this class of diseases. It is not possible to detect that special weakness of tissue present in some youths whose parents have suffered from tuberculosis. It is frequently not until some years with the colours have elapsed that this weakness shows itself and the disease develops—as a matter of fact it frequently does not show itself at all while the man is in the service, or the man completely overcomes the susceptibility to the disease.

The acuteness of vision required is only a quarter of what is normal vision in each eye and one-sixth in one eye provided the vision of the other is fully up to normal. The vision test with the regulation test-dots as practised for the Native Army is far from being a perfect way of measuring the eyesight. It is by no means uncommon to be obliged to invalid men for errors of refraction subsequent to enlistment, which

could not have been discovered by means of the test-dots alone. We require to be provided with more accurate means of testing the refraction or acuteness of vision of recruits than those now in use.

Recruiting in most of the Armies of Europe is less rigid than in our own, and medical officers are given much greater freedom for the exercise of personal judgment as to the fitness of candidates, and standards of height, weight, chest measurement, etc., are not rigidly adhered to, these being used as guides only

Exercise.—Before considering that part of the physical development of the soldier that concerns us here, it may be advisable to make a few remarks regarding the uses and effects of physical exercise in general.

We move our limbs with the fleshy parts of our body, which are called *muscles*; those which are under our control are called *voluntary muscles*. There are about 500 such muscles in the body, each having its special use, and all working in harmony.

Action and structure of muscles.—Muscles have the power of contracting or decreasing, and relaxing or increasing in length. The muscles are nearly all arranged in pairs, each muscle having its opponent, so that when they relax and contract alternately, the bones to which they are attached are moved. If we bend up the arm and close the fist firmly, we feel a hard lump in front of the middle of the upper arm. This lump is the biceps muscle which has undergone contraction. If at the same time, we feel the muscles at the back of the arm, we well find it relaxed and soft. There are other muscles over which we have no control, such as that of the heart, and those found in the walls of the intestines and elsewhere; these are called *involuntary muscles*; these have a different structure and innervation with which we need not deal here.

The voluntary muscles are composed of very fine red fibres, and these fibres are made up of very minute cells, which cells, at their lines of union, give the muscle a striped appearance. Hence voluntary muscles are called *striped* or *striated muscles*. The cells are filled with a living, semi-fluid (protoplasmic) substance. The fibres themselves

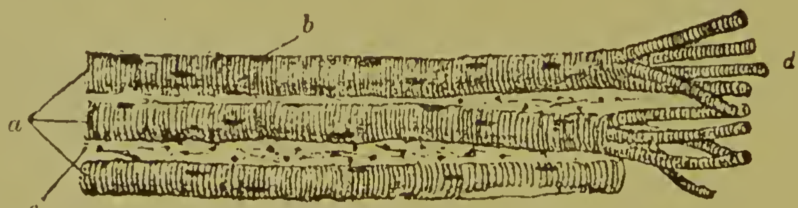

Fig. I.—Three muscle fibres (*a*), with their component fibrillæ (*d*) teased out; their nuclei (*b*), and covering (*c*).

are bound together in bundles, and the ends of these bundles are usually hard Muscles by regular use get strong. Want of proper use, or

their improper use, causes them to decrease in size. Every part of our body must be properly exercised if we wish to keep healthy. Some people take too much exercise in one direction, using one set of organs or tissues too much, while they neglect the use of the rest.

If a muscle be constantly exercised its efficiency is increased according to the call made upon it. The absolute force of a muscle, *i.e.*, the weight it is just able to lift, depends upon its cross section or the number of fibres which act together in raising the weight. If, therefore, the strain on a muscle is constantly increased the muscle tends to grow and increase its cross section. Thus, if it is desired to increase the size of muscles, we must ensure that they are constantly exercised against a force which is greater than that which they have normally to overcome. On the other hand, ordinary exercise does not necessarily increase the size of muscles, for it is well known that many men who are able to keep up prolonged exercise have only small muscles—for example, Natives of India. We may conclude, then, that exercise improves the efficiency of a muscle and its power of resisting fatigue, whilst increased strain causes increased size of the muscles. Therefore the arm and leg movements of the Swedish system cannot, under the circumstances, produce developmental effect in the ordinary acceptation of the term, and further the system as applied to recruits, while it does aim at the *development* of the trunk muscles and harmonious action of the muscles generally, does *not* aim at the *development* of all the muscles of the body.

Effects of exercise.—Let us briefly enquire as to how exercise affects us. In sitting we breathe much slower than when running. When we breathe fast we take more air into the lungs, and, the more pure air taken into the lungs, the better is the blood purified. The heart also during exercise works faster, and drives this purified blood all over the body more rapidly than when we are breathing tranquilly; the waste matters in the tissues are removed more rapidly, because the blood washes them out of the body more speedily. The body is therefore better nourished by exercise. All these effects create a good appetite and increased power to digest food. After the brain has been working for several hours it contains a lot of waste matters and requires rest. These waste matters interfere with the proper action of the brain, that is, the mental processes. Exercise is the best means of getting rid of these waste matters, for by it we send a fresh supply of pure blood to the brain which, in going back to the heart, carries away the waste matters—the blood washes them out as it were.

During active exercise great strain is thrown on the heart, blood vessels, and lungs, the activity of the circulatory and respiratory systems being largely increased. By accelerating the circulation and respiration the disintegration of worn out tissues and removal of effete waste products is expedited, and the formation of new tissue is facilitated—exercise hastens both waste and repair.

All the voluntary muscles are richly supplied with blood vessels (which carry blood for their nutrition, repair and storage of reserve material) and with means by which they are brought under the control of the will. They are the mechanical power, the physical vigour of the body. The best exercises are those which bring most of the muscles into play.

By the activity of the muscles an impulse is given to the blood going through their arteries and veins, and it is thus forced with increased momentum into the capillaries Exercise aids digestion, keeps up the functions of the liver and intestines, prevents constipation, and helps to use up any excess of proteid material in the circulation. In the absence of exercise the tissues of the body are liable to become soft, flaby and fatty, the muscles waste, and if subjected to any sudden strain or activity, they or their tendons and the structures in and around joints, are liable to tear or give way ; the heart being a muscle may similarly give way or be greatly disturbed by any sudden or prolonged effort. A man may by a rigidly abstemious diet lead a physically inactive life with exemption from disease, and may even live to old age, but he can never possess all the alacrity of body and exaltation of animal spirits of which his nature is capable, and which make life itself an enjoyment. His circulation must be languid, the waste of material small, and the demand for new supplies of material limited ; there is low vitality and a weak digestion.

Training.—Training is necessary in all cases where any severe or long continued physical effort is to be made, in order that all parts of the body is rendered equal to the task.

Graduated exercises have been found of great use in traiuing recruits for military service, but in all cases they require to be properly carried out under proper supervision. Excessive or violent exercise, especially if carried out with insufficient food, or without previous gradual training, may give rise to serious damage to the heart, lungs and body generally.

One of the first steps in physical culture is to recognise the neeessity of beginuing and carrying out a series of systematic exercises, and to take a real personal interest in the development of the body. Exercise should be adopted to meet the requirements of the individual. The object cf real physical education is to establish health and a good constitution, and fit the individual for the duties aud work of daily life.

Essentials to be aimed at.—The essential objects to be achieved in the preparation of the soldier for war are—to progressively increase his reserve of physical capital, to keep adding to the muscular power of his heart, the vital capacity of his lungs, the strength, activity and co-ordinating power of his muscles, and, at the same time, to quicken his intelligence. When these have been accomplished, the soldier is thoroughly traiued and fit in every sense. Men in this condition of fitness are in every way superior to those less traiued—they do not knock under after a forced march, they can go on a smaller allowance of food, bear loss of clothes, vicissitudes of temperature, and withstand exposure ; minor ailments and injuries have little effect on their efficiency, and even the more severe wounds when not in vital parts, heal more rapidly and enable them to return efficient soldiers to the fighting line once more.

Early physical exercises in the Army.—It was not till about 1840 that the Armies of Europe began paying any serious attention to the physical development of their fighting men. This commenced with such athletic exercises as gymnastics, bayonet exercise, and swimming. The time is probably not remote when gymnastic exercises, swimming, and athletics generally—all useful in any walk of life—will form part of our national educational system as they are now in Norway, Sweden, France, Germany, and several other Continental countries. These will not only tend to improve the physique of the nation and of the individual, every youth at school going through a complete system, but will considerably shorten the period required for training the soldier when he joins the Army. One would even go a step beyond this and welcome the day when not only physical, but military training also, will be made compulsory in all schools in the United Kingdom.

Recruits' course of gymnastics and drill.—To effect the development of the present day recruit, he is put through a six-month's course of gymnastics, physical and other drills. This early period of a recruit's development is all-important, and in all regiments should be under the careful supervision of the adjutant and medical officer. When the medical officer sees any undue disproportion in the exercises, or injurious influences from them in particular men, he should either temporarily stop or modify them, in accordance with special requirements. He should keep his eye constantly on recruits and young soldiers, and advise the adjutant where there are indications of working them under too high pressure, or "forcing" their physical development

Evil effects of misdirected training.—The medical officer should specially watch the influence of the training on the circulatory and respiratory systems, noting any palpitation or breathlessness and any cases of rapid wasting. One has seen many regiments in which there has been an inordinate number of "heart" cases amongst recruits. Special exercises for recruits are frequently being introduced, or old ones modified. One now much in vogue is that of increasing the difference between the maximum and minimum movements of the chest walls. The medical officer knows that this is not a reliable test of the real expansion of the lungs. A common error made by recruits is filling the upper and middle parts of their lungs at the partial expense of the lower. The collar bones and shoulders are raised, as is also the upper part of the chest. There is a slight movement upward and outward of the chest, while the lower part of the lungs remains passive, the diaphragm being but little used. When breathing is correctly performed, in inspiration there is practically no movement of the collar bones and shoulders, but merely an upward and forward movement of the sternum or breastplate, more specially its lower part, combined with elevation of the ribs and relaxation of the abdominal muscles, the reverse occurring in expiration. The diaphragm is the muscle which chiefly helps in expanding the lower part of the lungs, and the diaphragm is as amenable to development as any other muscle. Under a proper system of physical training of recruits the capacity of the lungs naturally increases without any special exercises such as abdominal breathing, etc. The advantage of such exercises is to

teach the recruit to breathe in such a way that he brings all the ordinary muscles of respiration into play properly. The increase of the lung capacity depends, of course, largely on the mobility of the chest walls, hence within reasonable limits, the younger the recruit the better results to be anticipated. The habit of breathing properly tends to the development of a roomy thorax, which is usually associated with a strong heart—two potent factors in resisting invasions of disease. The extent of real expansibility of the chest walls, and of real expansion of lungs, is one of our great tests of capacity for sudden and sustained effort.

The practice of deep breathing exercises during gymnastic exercises is unnecessary, and probably of very little if any use. Men should from the beginning of their career as soldiers be taught to breathe through the nose. Mouth breathing keeps the mouth dry, and like tobacco-chewing, encourages thirst.

Expansion of the chest and expansion of the lungs are not synonymous terms. The expanding lungs not only open out the air spaces, but also the blood spaces, which by drawing blood in, relieve the right heart. These spaces are not opened out unless the lungs are expanded in their more important diameter, the vertical, by means of the diaphragm; and unless they are opened out the respiratory movement does not assist the heart, which has to pump against increased resistance. When a man keeps his chest expanded with sinking in of the "pit of the stomach" and abdominal wall generally, the lungs are increased in the transverse diameter, and not at all, or very little, in the vertical diameter, and the venous spaces and capillaries are indifferently or not at all expanded; only the superficial parts of the lungs are expanded, the deep parts are unaffected. Further, if a man maintains a rigid posture, the burden on the heart is still greater, because the burden of the circulation is greater in a group of muscles in a state of rigid contraction than when contracting and relaxing.*

Medical officers should know that adjutants of regiments always appreciate thoughtful advice given them regarding the training of their recruits. The gymnastic and drill instructors must be patient with developing lads—neither the heart nor the lungs must be forced—error in this direction is constantly spoiling promising recruits; and, lastly, the exercises should be so varied as to give a due proportion of work to all the muscles that are being trained.

Medical examination of recruits during exercise.—When examining recruits at the gymnasium as to the effects of the exercises on their hearts and respiration, it is advisable for the medical officer to wait for 5 minutes or so after such exercises, as it takes about this time for these organs to resume their normal state after, say, 10 minutes' exercise. Should the heart and respiration not regain their normal condition after 10 minutes, such cases should be carefully watched, and, if necessary, the exercises modified, or they may have to be temporarily relinquished. In a very small proportion (from 1 to 2 per cent roughly), various conditions may be met with in the heart—hypertrophy, dilatation, temporary disturbance of its nervous apparatus, etc.; but most frequently what arises is a mere loss of muscular tone. We find great variation in the number of beats per minute in recruits who are perfectly fit, and by repeated examination we become acquainted with the peculiarities in this respect of each recruit.

* Lieut.-Colonel E. H. Deane, R.A.M.C., *Journal of the Royal Army Medical Corps*, October 1908.

Heart affections are exceedingly common among young soldiers. Its chief cause is a defective system of physical training, and unphysiological methods of conducting exercise drills. Comparing our European troops with those of other European Armies the number of heart affections are—British Army 7·3 per 1,000; United States 3·8; German 3·5; French 2·6; Russian 2·4; Austro-Hungarian 1·9. About one-third of our men so suffering are permanently invalided. There is every reason to believe that the excessive incidence in these cases is to a large extent preventable by a more rational system of training, and by the inculcation into the soldier himself of the simple fact that it is impossible to train if he smokes and drinks.

All passed recruits of our European and Indian troops are sound in all respects. Their hearts are carefully examined before enlistment, and no candidate with even a doubtful condition of the heart is accepted.

There can be no doubt that the physical training of former years was carried out too suddenly and was too severe, *e.g.*, the use of heavy dumb-bells, pulling up the body with reversed hands on the horizontal bar, etc., threw immense strain on the heart.

The comparatively large number of men annually invalided for some form of heart trouble led to careful inquiries regarding the effects of the physical training of the soldier. It may be safely asserted that heart strain and its consequences is the one and only condition of ill-health that can be in any way attributed to service in the Army. During the last ten years over 2,000 men have been invalided from our European troops for affections of the heart, or about 200 annually.

As stated above the number of soldiers invalided for heart disease has hitherto been far in excess of those of other European Armies. The average British recruit on enlistment is younger, less developed, and of a poorer condition of physique than in other European Armies.

The effects of the new system of physical training which was commenced in 1906 has already produced a beneficial change in our European troops, the number of men invalided for heart affections has been much reduced. This system has not been in operation amongst our European troops long enough to test its merits beyond stating that the results show an improvement on the old. It has so far not been officially introduced into the Native Army but most regiments use many of the exercises in training recruits.

The recruit is trained with a view to his being rendered capable of standing the strain and hardships of field service. The training of the fully developed soldier is maintained for the same purpose. This requires the soldier to be able to march long distances with his full equipment; he has to possess good power of endurance, be in good health, and be able to stand vicissitudes of climate, exposure, changes of food, and sometimes a scarcity of diet and unhealthy surroundings.

"To secure this end it is of the first importance that all physical exercises of the recruit and trained soldier be carried out with due regard to elementary physiological facts and principles. It is not sufficient to develop and train certain external or groups of surface muscles alone and to neglect the heart, lungs and other internal organs, for it is on these internal parts, notably the heart and lungs, that the body as a whole depends, not only for its fitness, but for its very existence. Failure in the past to recognise this fundamental idea has been the cause of much undoubted harm to the young soldier."*

A properly graduated system of physical training, if adopted early and continued for a sufficient length of time, will achieve the harmonious development of the whole body. The system laid down in the *Manual of Physical Training*, 1908, or what is known as the *Danish drill* modification of the Swedish course of physical culture, is said to accomplish this. As applied to the requirements of the European recruit of our Army, only certain principles of the Swedish system are included, and it is limited, under ordinary circumstances, to a six months' course.

The Danish drill system of training differs in a very important respect from the one that was recently in operation in the Home Army, and in fact from all systems, in that it aims at progressive and harmonious development of the trunk muscles; the development of the muscles proper of the limbs in the strict sense of the term is practically disregarded, while the aim of the English system has hitherto been exactly the reverse.

The system of training is based on anatomical and physiological data, and, when it is practised, medical officers of units should guide such training when they find that this is necessary. All medical officers of the Royal Army Medical Corps now go through a course of this training and are thoroughly conversant with it.

The subject of physical training has for years been looked upon as purely a matter of development of the muscles and training for drill work, and considered to be that it was outside the province of medical officers. Powerful muscles alone are insufficient; the state of the heart and lungs and other internal organs is not to be neglected, and requires the medical officer's attention.

In training the recruit it is wrong in principle to develop a few groups of muscles in a short space of time. What is required is a uniform development of all the muscles of the body.

"In the special training of the *soldier* in order to fit him for his life as such, apart from the technical training of the branch of the service to which he belongs, the following requirements should be kept in view—*viz.*, a soldier should be well disciplined, a good marcher, intelligent, smart, active and quick, able to surmount obstacles in the

* FIRTH'S *Military Hygiene*, p. 92.

field and capable of withstanding all the strains and hardships of active service. The required condition of physical fitness necessitates that the heart and lungs should above all things be sound and healthy; but the harmonious development of the *whole*—the skeleton or framework, the internal organs (including the brain and nerves) and the muscular system—is necessary to produce this condition."

In a system of physical training, the exercises used should ensure the *harmonious development of the entire body,* and in doing so they will correct any faults of previous one-sided development from whatever cause.

From these preliminary considerations we see, then, that the recruit requires some form of physical training before joining the ranks, the vast majority require special training, and from the early age at which they join the service it is reasonable to hope that all but a small fraction (less than 1 per cent.) will go through this, and achieve the object aimed at; the method of training is definitely related to the requirements of the recruit.

The following is the general outline of the principles on which the present system of instruction is based:—

(*i*) **The exercises.**—Every exercise employed has a beneficial effect on some part of the body and furthers at least one of the objects of the training. None of the exercises are harmful, and it is the sum total of all the exercises employed that produces the required results. Thus there are exercises for every part of the body, and, in addition, exercises of co-ordination (balance, marching, running, jumping, etc.,) to ensure harmonious working of the whole.

(*ii*) **The daily lesson**.—In every lesson exercises are given for every part of the body as well as exercises of co-ordination, and they are arranged in a certain sequence in order that the best effects may be obtained from them.

(*iii*) **Progression.**—The lessons are arranged according to the capacity of the individual, gradually increasing in difficulty from week to week and month to month, so as to ensure steady and systematic progress throughout the course of training.

The exercises are arranged in groups—arm, leg and neck exercises; span bending, heaving, balance, lateral, abdominal and back exercises; marching; running, jumping and vaulting, and corrective exercises, together with certain exercises added for practical application in the field.

Each lesson should consist of a series of exercises easy at the commencement and gradually increasing in strength at the end, so that at the conclusion of the lesson the circulation, which has been considerably accelerated by the stronger exercises, is sufficiently restored to its more normal state to enable the pupil to proceed to his other work without any feeling of undue agitation or fatigue. In the course of a lesson, short periods of comparative rest are arranged for by taking a somewhat easier exercise after a harder one, or an exercise which gives totally different effects. The table on p. 10 of the *Manual of Physical Training,* 1908, gives an excellent illustration of this arrange-

ment. It is a mistake to select and practise a few exercises until the pupil is perfect in them.

The main consideration in this system is given to the effects of the exercise on the heart and lungs; and no exercise in the *Manual* causes any injurious effect on these organs. Some of the exercises would cause strain in a beginner, but not if the same man has been some time in training. There is to be a steady progression by means of which the body in general and the heart and lungs in particular are gradually strengthened and worked up to a state of fitness to discharge the work required of them.

The earlier exercises are the simplest, easiest, and most suitable for weak or untrained recruits, and they gradually increase in difficulty and strength towards the end, so that a selection can be made from these later exercises sufficiently advanced to give plenty of work and full benefit from that work to the strongest men.

All exercises are performed from a certain position—such as "position of attention," "feet open," etc. These positions are strictly adhered to, *e.g.*, the angle and degree of separation of the feet should be correct, the weight should be balanced equally on both sides, and balance should be maintained by the engagement of the spinal muscles when in any movement the point where the centre of gravity of the body normally rests is disturbed.

Standing quite erect brings into play the action of many muscles, and the muscular effort is increased if the heels are kept together, for the base of support is a narrow one, and the balance must be finely adjusted. The position is really an unnatural one for those whose trunk muscles are not developed, but it can be achieved by any one *with effort*, and be maintained for a reasonable time without any fear of harmful effects following.

Any factor introduced while the erect posture is maintained which disturbs the equilibrium of the body (balance) will increase the muscular effort required to maintain that position; such a disturbing factor is movement of the limbs. Graded exercises are therefore introduced for that purpose, and just in proportion as they disturb equilibrium so is the muscular effort to maintain the erect posture increased. In this way gradual progression is accomplished, and by continuously and progressively engaging the trunk muscles throughout the whole series of exercises, development of these muscles is attained. If this is accomplished to the desired degree the defects associated with insufficient development will be corrected, and a natural erect carriage will be maintained *without effort*.

Arm and leg exercises.—"Apart from the equilibrium disturbing influence exerted by these exercises they also make the limb muscles proper active and the joints supple, and they enable the trunk muscles, not immediately concerned in maintaining the erect posture, to be called into action. Thus in heaving and rope climbing exercises, the hands and elbows are so placed that the limb muscles proper are as much as possible thrown out of action to produce full trunk muscular effort. This introduces another important principle, *viz.*, economical expenditure of energy. For example, a difficult exercise or feat of strength will quickly produce fatigue in the muscles specially used. If a man climbs up a ladder on hands and feet, he does a certain amount of work but experiences no fatigue. If he climbs up the ladder by hanging on the rungs with his hands, he accomplishes the same amount of work, *i.e.*, he lifts his body through the same height, but the sensation of fatigue in the muscles may be severe. Though the amount of work done is the same, it is at some disadvantage by the small muscles of the arms instead of by the large muscles of the hip; similarly, if he raises his body with the small arm muscles instead of with the large shoulder muscles the work is done equally uneconomically."

Arm and leg exercises are few and simple and the same movements are applied to various exercises. Their chief purpose is to disturb the balance; the movements of legs, *e.g.*, "feet placing," "heels raising," leg raising," and those of the arms, *e.g.*, "arms outward" or "upward stretch," all increase the difficulty of maintaining the balance and proportionately produce developmental effect in maintaining the erect posture or position of attention. The various simple movements of the limbs in these exercises have but little effect on the development of the limb muscles themselves. Muscular development is a matter of secondary importance. It is unnecessary to remark on the various other exercises as the several principles enunciated apply to all of them.

Apart from the above special training the recruit receives instruction in marching, running on the square, digging, etc., all of which form part of his later physical education after he joins the ranks.

Adherence to the foundation of the system, the progressive development of the trunk muscles, enables any one to understand the objects in view and easily recognise faults in the execution of exercises. Stability is necessary if work is to be performed efficiently and economically; therefore stability must be systematically developed. By the judicious application of this system we possess the means of correcting any unequal development of the body muscles.

"The Swedish system of training, as applied to the recruit, is based on scientific and sound common-sense principles, but it requires to be carried out by instructors having an intimate knowledge of its application; and the assistance of medical officers, who on account of their specialised education, are best fitted to guide them, is imperative, if full advantage is to accrue to the recruit and to the Army. A clear and comprehensive statement as to the aim and method of accomplishment of the present system should occupy a prominent place in the *Manual of Physical Training*, and so further that degree of co-operation which should exist amongst those directly and indirectly concerned in the training, if the best results are to be obtained."

Every means practicable should be adopted to prevent accidents during gymnastic work. We have always several cases under treatment for (usually minor) injuries sustained in the gymnasium. The more gradual the exercises the fewer will these be. There should always be an instructor ready to "save" lads in case of necessity, especially in vaulting. In saving them the body and not the legs should be grasped.

When the exercises are not carried out on the bare feet, as is the case in regiments in the Native Army, it is desirable that in the gymnasium each man have his own pair of shoes and, if practicable, these should have rubber soles, which prevent the jars that may arise from leather soles.

The same general principles apply to both our European and Native troops. Most of our European troops have, of course, already gone through their physical training at home. It is very desirable that the Swedish system as now adopted for recruits of our European troops should be introduced into the training of recruits in the Native Army.

"The danger of trying to hurry physical training should be recognised by all. It is impossible to obtain good results by cramming more and harder work into the same or less time. If therefore a shorter time than usual is available for training, the work must not be hurried or increased, but should be regulated accordingly, and no attempt must be made to attain the same standard that can be reached in the longer period of time."

The strong and active must not have special attention at the expense of the weak and clumsy, but rather the other way. The object is to train every man to a reasonable state of efficiency, and not to train a few only who are naturally athletic to a very high standard. It is the weak and awkward men who require most attention.

Sometimes under the advice of the medical officer weakly men have to be kept back, but the course is so gradual and progressive that this is only exceptionally necessary. "Instead of pushing on men of exceptional intelligence, strength, and activity, by transferring them to more advanced squads, such men should be made use of by the instructor to assist him by setting exercises, illustrating the work, etc., and encouraging others by their example.

The men should work in shirt sleeves and "shorts," drill trousers, or *dhoties*, and wear belts. The belts should not be tight, they are merely to support the "shorts."

Men should always arrive quite clean for their work, and they should be instructed to rub themselves down after any work which causes free perspiration, under which circumstance it is also advisable to change the clothes if this is practicable. In the winter great-coats may be needed going to and returning from the gymnasium, and in the rainy weather water-proofs. As much of the training as possible should be conducted in the open air. Physical exercises in the morning should not be carried out before the men have had some food, nor within an hour of a meal.

The gymnasia in which recruits are exercised should (if not an open shed) be thoroughly ventilated; all windows and doors should be opened; too many recruits should not be exercised at once; it should be thoroughly clean, free from dust or the dust should be allayed, and all spitting about the floor should be strictly forbidden. Men when heated should not be kept standing in a draught. The floor should never be slippery.

Necessity for thorough training.—On the thoroughness with which the individual recruit is trained and instructed depends his future usefulness as a soldier.

When the recruit's course is finished the man is passed into the ranks and is considered to be a trained soldier, and he has yearly to go through further physical exercises to keep him fit for his duties.

The completion of the soldier's training is carried out after he joins the ranks, and with the view to enable him to do so satisfactorily and without damage to himself, there is a further course laid down in the *Manual of Physical Training*, 1908. It should be remembered that the exercises are not practised for the sake of the exercises themselves, but for the effects they are intended to bring about.

Physical exercise signifies the exercises given to the soldier under company, squadron or battery officers and non-commissioned officers, after the man has been trained, and they are intended to fit him for the soldier's work. "These physical exercises should be given to the men when necessary throughout the year, and especially during the winter months, and whenever the manœuvre or other work of the soldier is not sufficient to keep him in the required condition of fitness."

A set of tables suitable for this physical exercise is given at the end of the *Manual of Physical Training*, 1908. They are arranged progressively on the same general principles as the whole system of training, and due care should be taken that they are used according to the condition and requirements of the men, *e.g.*, when men are comparatively "soft" on returning from furlough, discharge from hospital, etc., the table of easier exercises should be used.

It should be remembered that a high degree of "smartness" is not absolutely necessary for efficiency whether on parade or elsewhere. This means rigid and immediate obedience to words of command with strained attention and sudden movements which tend to react on the heart. Men should also be occasionally practised regimentally in running, jumping and surmounting obstacles according to the instructions contained in I. A. O. No. 167 of 1909.

This order states :—Non-commissioned officers and men trained under the system laid down in *Training Manuals, Appendix* 1905, will continue such training as heretofore. This training will include—

(*a*) *Progressive running* up to 1,000 yards; at first in shirt sleeves, without rifles or equipment, afterwards in marching order.

(*b*) *High jumping.*—Standard to be attained 3′ 6″ without rifle, 3′ with the rifle.

(*c*) *Long jumping.*—Standard to be attained, 12 feet without the rifle and 9 feet with the rifle.

(*d*) One hand vaulting, elbows high.

(*e*) Obstacle course.

2. *British Troops.*—Non-commissioned officers and men trained out of India according to *Manual of Physical Training*, 1908, will not be taught the exercises in "Physical Training, with or without arms" as laid down in *Training Manuals, Appendix* 1905, but will continue the new system if there is a qualified non-commissioned officer in the unit available to superintend.

3. Should there be no instructor qualified to carry out the instruction for men referred to in para. 2, the training will be as laid down in (*a*), (*b*), (*c*), (*d*), and (*e*), para. 1.

Indian Army.—The training laid down in *Training Manuals, Appendix* 1905, will be continued as at present with the addition of (*a*), (*b*), (*c*), (*d*) and (*e*) in para. 1 of this order.

The writer has consulted several adjutants on the relative merits of the old and the new system of training and they mostly were in favour of the old system as bringing on recruits more rapidly and fitting them for duty in the ranks more speedily than the new system, although they admitted that it necessitated the ultimate rejection of a larger number of youths. On the old system one has seen many promising lads break down and become permanently unfit in consequence of the severity of the strain. The admission rate into hospitals amongst recruits is higher than amongst the fully developed and older soldier.

A definite uniform system necessary.—Whilst there must be some definite and uniform system of training the physique of our soldiers, one which develops to the best possible degree the vast majority of them, we should not forget the personal equation in individual cases of men who cannot stand the strain of severe training, and who may yet make thoroughly efficient soldiers. We see this frequently in the varying sensitiveness of different horses iu training to race. It will be borne in mind that the undeveloped lad cannot do the same work as a hardened and seasoned soldier—they do not yet possess the same powers of endurance, nor anything like the same resistance to disease causes, whilst a scanty and unsuitable diet lowers them much more rapidly. European and Native soldiers of 20 years of age cannot be compared as fighting men, with men in the ranks of 25.

Premature fitness a mistake.—Men should never be passed prematurely into the ranks as trained soldiers merely to increase the strength of the regiment. Such a blunder serves to tax those who are efficient. * "The time of the year at which the annual training begins and ends, and the method of carrying it out, will differ in various parts of the world, being mainly determined by considerations of climate. Field training and manœuvres are most instructive as a training for war, when war conditions and the energies to be called forth are the same as in war and kept in view."

During manœuvres, of course, as distinguished from actual field service, climatic conditions must decide the extent to which troops can be bivouacked. The less troops are dependent on camps, the more instructive will be the exercises, the greater their mobility, and the smaller the expense.

The unseasoned soldier a burden in the field.—The ranks of unseasoned troops are apt to be rapidly depleted when called upon to

* *Combined Training*, 1905, p. 15.

march under the conditions of active service. Infantry fall out from sickness and sore feet. Advantage must therefore be taken of every opportunity to accustom troops to marching and thus bring the feet and muscle of men into condition permitting of severe and prolonged exertion.

The soldier must be trained to be hardy.—Men must also be trained to be hardy. Without this quality, without the capacity to stand heat and cold, hunger and thirst, and fatigue, a soldier may be found wanting at the critical moment. A brave heart and firm resolutions fail, when the flesh is incapable. We cannot, of course, expect our town-bred men to equal in this quality our coast fishermen, who have been hardened by generations of exposure, nor like the trained Alpine mountaineering guide, but we can do a great deal in this direction. Russian soldiers are taught to sleep out in the open air in the coldest weather, they do their route marching often in snow storms. One is greatly disposed to think that most of us eat too much, drink too much liquid, dress beyond the requirements of weather (that is, we clothe too warmly), and sleep on too soft beds. The rigid use of sterilised water will not keep a soft and defectively trained man from falling out on a hard day's march, or enable him to endure the fatigues, hardships, and exposure of a severe campaign. Hygiene in the field does little to help the man who is weak and wanting in endurance. We know, of course, that it is not always easy to harden the town-bred man, whose previous mode of existence has been opposed to that of a life of endurance. Nevertheless by proper training, feeding, etc., such men are often amongst our most excellent soldiers.

Out-door games and sports are invaluable auxiliaries to physical training; they are complementary to one another; some form of active recreation is almost an essential to the completion of physical training.

Methodical arrangement of physical exercises and outdoor games develop manly vigour. We see this quality brought out in those who indulge in shooting, out-door sports, and out-door games generally. The football player has not only developed his muscles; he who has rowed in his college eight has done more than learn how to negotiate the sliding seat. The exemplary players of our manly out-door games have learnt more than the games at which they excel—they have been through a training in which they have acquired courage, pluck, self-reliance, endurance, quickness of eye and hand, and promptness in judgment; they understand what discipline and self-control are, they fully appreciate what we mean by good-fellowship and loyal comradeship; they will have learnt what it is to be patient, to be fair, to be unselfish, to be true, to be frank, straight-forward and wholesome-minded.

Out-door games, however, can never take the place of physical training. "They have not the same corrective effect, many of them are one-sided, the same regular, systematic and progressive results cannot be obtained from them, and, apart from the difficulty of

obtaining space for all to play, the greatest drawback to the use of games alone is that the weaker and less expert performer (*i.e.*, the very man who most requires training) is often discouraged by his want of proficiency and so ends in becoming a looker on."

It was not until one visited practically all the great training schools for the youths of Japan — Tokyo, Osaka, Kioto, Kobe, Nagasaki, Hiroshima, Yokahama, etc.—that one quite understood how it is that the Japanese *simurai* is such a hardy warrior. In these schools one saw children of 7 or 8 years daily go through their lessons in the various forms of *jiu-jitsu*, sword exercise, physical drill, etc., and they continue to do so until the time they enlist, so that when *simurai* is 15 or 16 years of age, he is physically thoroughly trained and requires little but special training after entering the Army The Japanese Army has included a modified Swedish system to complete the training of the recruit.*

Acquired communicable disease in the Army in India.—Before leaving this part of our subject it is specially necessary to insist that nothing that happens to our men in the Army should interfere with the quality of our future recruits, and we should see that any transmissible diseases which they acquire by accident or otherwise in the service is treated in the most approved way before they are invalided, and, if possible, arrangements made to continue such treatment after they leave the Army. We should remember that the men of our Indian Army (European and Native), whom we invalid to their homes with communicable disease, may sow the seeds of such disease in their homes, or may even become the fathers of our future recruits, the disease or the tendency to it being inherited by such recruits. A few instances will illustrate one's meaning. We are yearly invaliding a large number of both British and Native troops to their homes for tubercle of the lung. In the interest of the efficiency of the Indian Army it is imperatively necessary to eliminate every case of tubercle of the lung as soon as a positive diagnosis of that disease has been made. In this we have no choice. For practically, the prospects of an ultimate cure in an odd case or two are so meagre that they may be neglected, and the risk of disseminating the disease during such ineffectual efforts at cure are very decided. We are at the present time invaliding to Nepaul annually about 65 Gurkhas for tubercle of the lung (or other form of turberculosis).† In most of these cases, probably

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* In this section on PHYSICAL TRAINING I have been specially indebted to *Manual of Physical Training*, 1908; MUNSON'S *Military Hygiene*, Colonel FIRTH'S *Military Hygiene*, Major BLACKHAM'S *Military Sanitation*, Capt. H. BOULTON I.M.S., *A Hand-book for Officers of the Indian Medical Service in Military Employ*, articles and notes in the *Journal of the Royal Army Medical Corps*, especially Lieutenant-Colonel E. BUTT'S *Swedish System of Training*, and Lieutenant-Colonel DEANE'S *A Plea for a More Detailed Study of the Soldier's Heart*.

† One recalls the terrible epidemic of pulmonary tuberculosis that occurred in the two battalions of the 4th Gurkha Rifles in Bakloh, for which disease in 1903-04 over 200 men had to be invalided.

in the vast majority, the disease is acquired in the Army in men, who at the time of enlistment had an undiscoverable susceptibility to it. It is fully established by scientific medical evidence that pulmonary tuberculosis is a communicable disease. Our present daily practice in regimental hospitals (and that in practically all the Army hospitals in Europe) of isolating such cases, and destroying, by incineration or through disinfection, the expectoration (which contains the bacillus tuberculosis, the essential cause of the disease) of such patients, is based on this indisputable fact. By sending back over 65 invalids suffering from this disease to their native villages in Nepaul, we are creating new foci for its dissemination, and as it is seldom that two or more men return to the same village, the number of new possible centres of infection in the course of ten years or so would be considerable. We might urge the necessity of isolation of such cases and the destruction of the expectoration, but it is extremely doubtful whether any formulary of rules would under existing circumstances be carried out. The possible evil consequences of this on our recruiting of Gurkhas a generation hence can scarcely be calculated, but one hazards the statement that the question is one fully deserving of serious and timely consideration. The Gurkha with pulmonary turberculosis knows that his malady is one which sooner or later will prove fatal, and when invalided has a natural craving to get amongst his people in his native home.

The same remarks apply to our Pathan, Dogra, Punjabi Musalman and Garhwali regiments; and also to our European British soldiers invalided to their homes in the United Kingdom.

Syphilis—its relation to inefficiency.—Syphilis (one means true specific, constitutional venereal disease, as described in PART IV,) is another transmissible disease which gives rise to a considerable amount of inefficiency and invaliding in our Army in India, notably amongst European troops and Gurkhas. Most of you are probably acquainted with the orders in existence in regard to the manner of dealing with these cases—that they must be systematically kept under at least a year's treatment. This is a most comprehensive and far-reaching order, which aims at restoring the efficiency of large numbers of men annually, and all combatant officers should lend their help to medical officers in the carrying out of the order. The men need as a rule only be in hospital during the initial and active secondary stage of the disease; for the remainder of the time they are at duty, attending the hospital once a week, or once a fortnight for treatment. One knows that carried out in its integrity, this system of treatment does restore efficiency in men who have acquired syphilis, and that in probably 70 per cent. if not more. The unfortunate victim of syphilis is never a *persona grata* in the service, and the prejudice against him in some regiments, is very strong. It is necessary from a disciplinary point of view that men should be discouraged from running the risk of

acquiring venereal disease in any form, but once it has been acquired, it is the medical officer's duty to restore the man to health as early as practicable. To the medical officer the victim of syphilis is a patient the same as any other man occupying the hospital wards, and has to be treated by him with the same care, consideration and attention. Another important point of the order referred to is that it includes the complete eradication of the disease, in a certain proportion of cases, and to that extent removes the chances of the men becoming the fathers of children who inherit syphilis, which children may some day be our recruits.*

B.—Marching.

Mechanical disadvantages in marching.—A capacity to endure long marches forms a constant and essential part of the soldier's training, and a reference to the subject of marching may not be out of place here. It is a truism to state that in a soldier marching in unity with a column, there is a certain amount of wasted energy. This is partly due to the restraint put on the physical freedom of movements of the limbs, and partly to the stiffness of the movement. No amount of special training can remove this fact. This training, however, is inevitable, and eventually the well-trained soldier acquires a sort of mechanism which enables him to keep step, and his place in the ranks, with the minimum loss of energy. We know that when a man is standing at "attention," he is exerting his muscle to maintain his equilibrium, because the basis on which he stands is small and not secure. On actual field service one of our duties is to conserve the energies of the soldier and to maintain the reserve of physical energy it has taken years of preparation to store up Hence we make our men "march at ease" or "stand at ease" whenever practicable—we avoid keeping them at attention longer than necessary.

In marching with the full field equipment the centre of gravity is being disturbed at every step, and this in a constrained way, as the lateral movements and freedom are limited; under these circumstances there is a constant waste of energy. Hence the physical advantage of marching at ease and in open order, in which there is less energy lost and the demands on the muscular system more deliberate.

Action of the feet in marching.—In marching the foot should only be raised from the ground as far as is required to clear any obstacles; nor should it be advanced beyond where it is to fall. It is well known that when the leg is at its greatest length, that is, when it has just urged the body forward and is lifted from the ground, it falls forward as a pendulum from its own weight, not from muscular action;

* For further remarks on *Venereal Disease* see Part IV.

and this advance is from within and behind to without and before, which action alone carries the limb outwards.

FIG. 2.—Military or straight-leg marching (after BRADFORD).

The soldier should, however, be taught to restrict this outward inclination or eversion of the foot. A moderate inclination of about 10° best answers all requirements, as it favours the broadest basis of support with the maximum of claw-like propulsive movement from the toes.

"Under present methods of marching the shoulders must be kept straight, the neck and body erect; the knees are only slightly bent and the feet are thrown out well in advance of the body, the free arm swinging naturally. In ordinary walking the heel touches the ground first, the greatest weight being borne by the flat of the foot, and the toe bearing the ground first. Too often the soldier is taught or acquires the habit of placing the foot almost flat on the ground, thereby increasing the shock of impact and personal fatigue. The foot acts as a lever of the second order, in which the basis of the toes are the fulcrum, the muscles of the calf attached to and hauling on the heel are the power, and the resistance is the weight of the body transmitted by the shin bones to the ankle joints In ordinary marching the toes should be directed well forward, so that the thrust backwards in the foot should be in the direction of its length and not across it."

Position of the body in marching.—In walking the whole body is projected forwards. In doing this the point of the centre of gravity of the body describes a circular movement in the form of an arc about the foot. The less the body is raised the less the labour. In long steps the arc, and the height to which the body is raised, are greater—in short steps, less. It is probable, however, that the angle at which the body is bent, and, of course, the co-efficient of resistance, are not

materially affected by the length of the step, so long as the speed is not altered. The 30-inch step of "quick time" with 112 paces a minute, when the fully equipped man is carrying about 40lbs., is the most economical for his energies. It is probable also, that under the same conditions, the 33-inch step of "stepping-out" time with 110 paces to the minute, is a trifle too long. The step in our Army varies from 33 inches at "the double" and in "stepping out," to 21 "in stepping short," and 24 in forming "fours-deep."

Most economical speed with field equipment.—It is probable that with the full equipment, the most economical rate in an ordinary 12 to 15 miles' march is about 3 miles an hour including halts, but excluding the longer half-way one. Small picked forces may go beyond this average for weeks, but large forces, even when consisting of chosen men, will rarely do so without great strain. The pace laid down in *Combined Training* for an infantry column is one mile per 18 minutes, and infantry should be practised to keep this pace for long distances. In war time it will often be necessary to make men go at "step out" rate for many miles. Men cannot do this if they have not been trained to it in peace times. Rapid marching without time limits for distances during route marches should be practised during peace times. These should not be competitive with other units.

Adherence to marching discipline.—Good marching depends largely on the efforts of regimental officers to give effect to the rules as to march discipline, contained in Section 23, pp. 23-24, *Combined Training*, 1905.

The natural step varies with individuals but it should not exceed six-sevenths of the height of the limbs, which in average soldiers is 27″; this is too short a pace for ordinary marching. The ordinary step in the French infantry is 29½″ at 120 paces per minute, and in the German 31″ at 112.

It is probable that the speed of the step should not exceed 120 per minute, as when the number of steps is increased the length is diminished.

In practice the men usually choose their own length of step. It is much easier for the average man to increase the number of steps per minute than the length of the pace. The greater the load of equipment carried the shorter should be the pace. The present equipment though the best hitherto employed will probably be improved on in the future, particularly in regard to eliminating the bandolier and using webbing instead of leather attachments.

Whilst there is more ease in marching in the ranks now than in former years, we are unable to remove the physical constrant inseparable from large masses of men marching in column. All men are not equally fit, and the indifferent marcher has to keep his place in the ranks with the good marcher.

It is not possible to make the marching of fully accoutred and equipped soldiers as free and unencumbered as that of the individual walking independently and unweighted, but our object should be to endeavour to approach this as far as practicable. What one would here emphasise is the necessity of permitting men to march without unnecessary limitations or restrictions—to move with as much freedom as the circumstances of marching in the ranks allow. At the end of the day's march the men should feel that they have had what is only a healthful amount of exercise.

Two or more converging roads preferable for a large force.—Where there are two or more roads of advance to the front, and even at the front, when tactical considerations permit, the force should proceed by these and not adhere to one road. There are administrative advantages as regards food, quarters and comfort, inherent in dispersion, as opposed to over-concentration, which will nowadays be duly considered *

Best time to march—The actual time of marching is governed by many considerations, such as the condition of the roads, state of the weather, and above all, by military considerations. Whenever possible the march should be early in the morning, for at this time the air is cool, the men are fresh after the night's rest, and the early start enables them to get to the next halting place before it is too warm.

Early morning marches in hot weather.—In the hot weather, the early morning hours are the best to march in all parts of the Frontier. The plan now generally adopted in marching in peace time is to arrange the march so as to arrive in camp by 9 A.M., or a little earlier, when marching in the hot weather. When a long march is to be undertaken with the prospects of a hot day, the Regulations advise that a halt of three or four hours should be made in the middle of the day. This allows men and animals to feed and rest, and is certainly a less fatiguing way of completing a long march under the circumstances. During the winter months, a start before sunrise is best. If the march, however, is a long one, and likely to be associated with many interruptions, it is better to start in the dark in the morning than to arrive in camp after dark in the evening. It is always advisable when practicable to ensure reaching camp at least before sunset.

Bad effect of night marching.—Night marches should never be undertaken, except for strategical or other military reasons or for training. Night marching in India is now almost universally condemned as a practice even in the hottest weather. Refreshing sleep is most important to our men; and in the hot weather, especially with an absence of shade, in dust, and possibly flies, men cannot sleep during the daytime. A small shooting party can of course march all night and find shade and shelter where a large force cannot. This is specially the case with our British soldiers, for they cannot sleep in tents during the day and soon

* *Combined Training*, 1905, p. 16.

knock up for want of rest. All experience shows that night marches eat into the soldier's staying power more than any other factor. Constant marching at night always leads to long lists in the morning state. Except under pressing military necessity night marches should not be continued as a routine in mobilising troops.

Exceptional circumstances alter this rule.—"Tactical considerations, the length of the march, state of the weather, and other considerations may oblige the force to start some time before day-break. It is preferable to start in the dark than reach the destination late."

The men should never begin the day's march on an empty stomach. What is required is a light meal before the march, tea or coffee with some bread or biscuits, or with Native troops *chappaties*, etc. Especially is this necessary with early marching as at that time the stamina is at its lowest, and the warm beverage sustains and rouses the men, lessens the sense of fatigue and adds to their resisting power against disease causes. A large meal should not, however, be given until the march is over.

The men should start with their water-bottles full, but restrain themselves from drinking as long as possible. The use of alcohol in any form during the march should be strictly forbidden. This rule should be absolute.

Average length of march.—The march *en route* to the front averages from 12 to 15 miles, but may vary from 8 to 18 or 20. A forced march is any distance from 24 to 30 miles and may occasionally be 40 miles, done in the 24 hours. Forced marching cannot without inordinate strain be carried on beyond 36 hours without a period of rest.

Duration of day's march varies with strength of column.—The length of time taken to do a day's march varies with the strength of the force and length of column. When only a few regiments are marching together without any interruptions, a 14 miles' march can be easily done in 5 hours. When 8,000 or 10,000 men are on the road together the same march will take it 7 hours, often longer; three Divisions will take 9 or 10 hours. Many circumstances delay marches, head winds—a strong wind acting on a large body of men will add from 10 to 20 per cent. in the time it takes to do a march—rain, and snow add 10 to 15 per cent. Great heat, dusty, sandy or muddy roads, darkness, steep hills, etc., are all factors which prevent the normal rate of marching being maintained. Including halts an Infantry Brigade should average three miles an hour. It is unsafe to calculate on a large force marching on a road more than two miles an hour. The darker it is, the slower will be the pace. The length of an average march for a column of all arms is 12 to 15 miles a day, with a rest at least once a week; small commands of sound soldiers on good roads can do 20 miles a day, but in extensive operations involving large bodies of units, the average rate of marching will not be found to exceed

12 miles a day.* Infantry do a mile in 18 minutes comfortably, and cavalry in 15 minutes walking and in 8 minutes trotting.

Condition of road.—The condition of the roads is always to be taken into account in estimating the fatigue, and wear and tear likely to occur in troops and transport animals. Fifteen miles on a good road is done by troops cheerfully and without any real fatigue; a similar distance after a severe thaw on a broken road, over an enemy's country, or even on a *katcha* road after heavy rain, would be extremely fatiguing to both men and animals. Throughout the whole of the 1814 campaign, in the deep and heavy soil of Champaigne, with bad country roads and unpropitious weather, the sufferings of the troops on both sides, who were constantly manœuvring, were aggravated to an intense degree.

Leading unit to keep regular pace.—In marching in column the officer of the leading unit should remember that he is at an advantage and those behind at a disadvantage. It is very necessary that he should keep a regular pace; an irregular pace, with checks and rushes, is very exhausting to marching men.

Open order on dusty roads.—In dusty and hot weather the column may with advantage be opened out on each side of the road, the centre of the road being left clear. The dustier the road the wider should be the open order. In very hot weather it may be necessary to open out a column by increasing the distance between sections of fours, and allowing an increased interval between men. This, of course, requires the order of the officer commanding the column.

Supply of water on the march.—"During the hot weather, arrangements for supplying the troops with water during the short halts should be made, either by means of water-carts accompanying the units, or by inducing the inhabitants living near the route to place buckets, etc., full of water at the roadside." In the enemy's country the medical officer should assure himself that the water has not been tampered with by the local inhabitants under instructions of the enemy. The Japanese were always cautious in regard to this matter.

Soldiers must be trained to restrain thirst.—Excessive drinking adversely affects a man's marching powers, and makes it difficult for him to dispense with a plentiful supply of water. Men are not to be permitted to fall out for water; when necessary, halts will be made to enable men to fill their water-bottles. It is difficult to interfere with thirsty men using their water-bottles, but we should take every opportunity of explaining them the inadvisability of deluging themselves with liquid unnecessarily, and that drinking to excess is largely a matter of habit. Men should refrain from drinking as long as possible, and when thirsty drink sparingly, and keep a reserve in the water-bottle. The

* *Combined Training*, 1905, p. 27.

putting of a few pebbles in the mouth, which keep the mouth moist by exciting the flow of saliva, is by no means to be despised as an assuager of thirst.

Straggling.—Straggling in marching should always be strictly interdicted. Nothing is more depressing and demoralising to troops than straggling, and it must at all costs be prohibited. Its special remedies are to have none but fit men with the force, removal of all sick and incapable from the ranks at once, and, in some cases, assistance. The men should be kept cheerful and in some way occupied The regimental band shortens the road as does also choral singing.

Halts on the march.—"Halts of 5 to 10 minutes are allowed after every 60 minutes' marching." The first halt might with advantage be made after the first half hour as this enables men to re-adjust any part of their equipment that is causing irritation, friction, or discomfort. Regular halts are necessary to rest the muscles and relieve their tension—5 minutes after each hour's actual marching. When the march exceeds 10 miles it is desirable to rest for 15 or 20 minutes half way. There is greater economy of energy in this than in doing a 10 mile march in two stretches of 5 miles each, with a comparatively long rest between them. Long halts are undesirable—they permit the muscles to stiffen and predispose to chills. The halt, however, should be a real five minutes. One frequently sees two of the five minutes wasted in forming up at the side of the road, piling arms and breaking off. Lord ROBERTS' march to Kandahar proved the use of the short halt by what the force attained. In all unusually long marches, when possible, an advance party should proceed to the half-way halt to prepare tea or coffee—and lots of it—for the men. In this case what is required is liquid warmth, which, in the shape of tea or coffee, is an excellent restorative.

Sanitation during halts.—The duties of the sanitary police are most important during the halt to prevent men rendering the neighbourhood foul and insanitary. It is urgently necessary that promiscuous fouling of the ground be prohibited. The moment the men are to halt the officer commanding should point out the place for the purpose, and the sanitary police should see that all men using it cover up all excreta with earth or that a sweeper on duty does so. Each man should make a shallow excavation with the point or heel of his boot, bayonet, *kukri*, or a stick, into which the excreta should be deposited, finally replacing the removed earth over the excreta. If this is not done and a large force is marching in column, a terribly disgusting state may arise, and a vast amount of preventable disease be created. This practice should always be carried out on the line of march and on manœuvres. It is of extreme importance. An alternate method is that the sanitary section men should accompany battalions or other units on the march, in the proportion of one sanitary section man per two companies. This man is to carry a spade. In British regiments Regimental Standing Orders should insist that:—(1) All men must

cover their own excreta with loose earth, scraped up with a bayonet, sword or a boot; (2) men except in very urgent cases must not be allowed to fall out between halts; (3) at short halts, say, for under half an hour, the sanitary section man should report to the senior company officer of the two companies to which he is attached, who will indicate to him a suitable place to which men falling out must go. The sanitary section man must at once proceed to the spot accompanied by the men wishing to fall out. He will either himself cover up their urine and fæces with earth, or see that the men do so in some way. No men should be allowed to rejoin their companies or column until this material is covered; (4) when halts are for longer periods than half an hour, or when outposts are placed, the sanitary section man must proceed as directed above to the spot intended to be used for excrement, and there dig a few short shallow trenches for defæcation and one shallow trench 3 inches deep as a urinal.* With Native Troops one sweeper per double company should, under the supervision of a sanitary section man, be employed in covering up all excreta with earth.

These orders should be rigidly enforced and the British officer of the day should visit the places, see that they have been left in a clean state, and report the fact (or otherwise) to the officer commanding. One feels sure that if men and officers thoroughly understood the dangers of the old custom of promiscuous defæcation and urination at every halting place without any precautions, the matter would receive the attention it deserves, and the men would fully co-operate in carrying out all orders on the subject.

Causes of falling out.—The chief causes leading to men falling out are—diarrhœa, colic, sore feet, faintness, and, in the hot weather, heat syncope. Dissipation and drink at night cause diarrhœa, and eating unwholesome or badly cooked or stale or decomposing food, causes colic and diarrhœa.

Care of the soldier's feet.—Proper care of the feet is incumbent on every soldier and must be insisted on by his officers and non-commissioned officers. In something like 25 per cent. of infantry soldiers the feet are damaged in one way or another during the first week's march. Even with every possible care and precaution a certain number of men suffer and are temporarily rendered inefficient from this cause. The chief causes of foot-soreness are—ill-fitting boots, holy or badly darned or dirty socks, and dirty feet.

The feet of all troops should be washed every day, and when water for the purpose is not available they should be thoroughly wiped with a wet towel or cloth, special care being given to wiping the toes and between them. Men who are inclined to have sweaty feet might use an ointment of 2 per cent. of salicylic acid in vaseline, or use daily a ½ per cent. solution of formaldehyde. The following powder is also useful:—Salicylic acid 3 parts, powdered Venetian talc 87 parts, starch 10 parts.

* Colonel R. H. Firth, *Military Hygiene*, pp. 260-261.

These applications are, however, not preventive. The proper remedy is good fitting boots and good socks, and insisting on the men cleaning the feet daily. It should be remembered that men with badly formed feet can seldom be good marchers and should not be recruited for the infantry.

One of the first cares of medical officers will be the state of the men's feet. For the first few days it is advisable to hold a daily foot inspection, and place under treatment any bad cases of blister or shoe-bites. He will at the same time see the men's boots and socks, advise regarding any defects he notices in these, and insist on the men washing their feet with soap and water at least once a day. The seasoned British soldier seldom omits to wash his feet at the end of a march and put on dry clean socks. It is no unusual thing to have to treat an average of 10 to 15 cases daily of shoe-bites, inflamed corns or bunions, ingrown toe nails, etc., during the first six or eight days' march. Taken early, the great majority of these are readily set right ; neglected and poisoned by septic germs, they may necessitate the man's being sent back to the depôt or to the base. A simple shoe-bite or blister in a thoroughly clean man is a very temporary inconvenience, whilst in a man whose feet are layered with dirt and micro-organisms, it may mean weeks of inefficiency. A lather of soap with hot water on the feet before putting on the sock, or even rubbing the inner surface of the sock with soap, saves many cases of foot-soreness. There are numerous other simple plans of preventing sore feet with which all military medical officers are familiar, and which they apply to individual cases. Foot-soreness from defective socks is always avoidable. Socks should be without holes, and when darned, the material used should not abrade the skin. If the men have two pairs of boots each, both pairs should have been taken into wear, and shaped to the feet, before commencing the march.

"Rubbing" of thighs.—Chafing of the inside of the thighs from rubbing of the trousers, or when wearing "shorts" without proper under-drawers, from dust and sweat, may be a cause of much discomfort. A drying powder of oxide of zinc and boric acid (1 to 3) or simple boric powder, the use of suitable drawers, and the practise of real cleanliness, are usually sufficient to relieve this.

Diarrhœa on the march.—On our N.-W. Frontier, especially when diarrhœa prevails, the falling out of men to relieve nature is always associated with risk. It is well to advise men to relieve themselves before the march begins, during a halt, or when the march ends. The medical officer will, of course, avoid the use of purgatives as far as possible, and when given, they will usually be of a simple nature.

Advice against chills.—The medical officer should at the beginning of the march forbid men taking off their upper garments because they feel hot and are sweating. This is the opposite of what should be done,

for the same reason that we put on a sweater after polo, racquets, or tennis. The risk from chill after great exertion, when the physical resistance is below par, is a real one, operating in various ways for evil. In hot weather the heat developed by physical exertion must be thrown off by the lungs and skin, if not, heat accumulates within the system, and heat-stroke or sunstroke may result. The soldier in marching in the hot weather with a full kit usually sweats considerably, loses water from the body, but the formation of heat under muscular action goes on. If the air is already humid, evaporation from the surface is interrupted. Again, if there be a scanty water-supply on the march, and he cannot replace the fluid lost, sunstroke may arise A full supply of water should be always ready at hand.

Great-coats seldom to be worn while actually marching.—When rain is expected the great coat should always be at hand. Men should, however, be discouraged from using their great-coats for every trifling shower of rain. While actually marching, rain will not, as a rule, do any harm. A great-coat weighing about 5lbs., when saturated with rain, is very heavy. It is better to have dry great-coats to put on over sweaty, wet shirts and khaki coats when the march is finished, than to have the great-coat also saturated. During halts in rain, of course, the great-coat should be worn. The men should be cautioned against the prevalent practice of discarding their coats as soon as they get into camp, and while waiting for the transport to bring up their tents. Their shirts are moist with perspiration, and they are then tired and very prone to chill. On reaching camp the men should be broken off at once, take off their accoutrements, but not their coats.

In marching on manœuvres or to the front and in the early part of a campaign, there will usually be a weeding out of seedy men, of those with latent disease becoming pronounced under the strain of service, and of those of poor physique; these latter being usually in the younger men.

Necessity of a weekly halt.—When marches are to be continuous, a halt of once a week is necessary to keep the men fit.

All men falling out to be given a name ticket.—When on field service a ticket with name, number, regiment and rank, should be given to every man who falls out on the march, except when he does so for purposes of nature.

On the march and at the front the medical officer inspects the men as frequently as possible, not formally or to worry them. He will avail himself of every reasonable opportunity of being amongst the men, and take mental notes of their condition. He will give orders that all cases of indisposition are to report sick at once. Men do not sham sickness when going on field service, and certainly never at the front. I have never known a man on field service to report sick without adequate cause.

Apropos of this, one remembers the case of a man of a Native Infantry Regiment in No. 14 Native Field Hospital in Mandalay in 1887, who had been wounded in the upper part of the right thigh several months previously, and constantly complained of severe pain in the region of the wound, long after it had healed. He was then a prisoner under observation for shamming sickness. A new medical officer on investigating his case, suggested that an operation was necessary. This was performed and a nerve tumour (what we call a *traumatic neuroma*) was excised from the external cutaneous nerve at the upper and outer part of the right thigh. From the moment of the operation the man did not complain of his neuralgia. This is a warning to officers suspecting men of scheming on field service.

The medical officer sees that rations are properly cooked and distributed, that the kitchens are clean, and the cooking utensils are cleaned ; that the men do not expose themselves to chill or the sun unnecessarily ; that they bathe themselves and wash their clothes when opportunities offer. When bathing in deep waters, a bathing piquet with ropes should be on duty while men are bathing. One has seen two cases of drowning with troops on the march We have several times seen crocodiles in Indian rivers and canals near where men of regiments were bathing. British troops should be warned about the dangers of the sun on the head when swimming. Not more than ten minutes' swimming should be permitted.

On halt days, he will see that the tents are opened out in the way described later on, the kits aired and sunned, that tent drains are dug, that the camp area is properly cleaned, and the latrines in as satisfactory a condition as possible.

Peace duties of medical officers are a training for those during war.—In a general sense, so far as individual regiments are concerned, the preventive measures on field service should be no abrupt departure from those adopted in peace times on the march and during manœuvres. On the march the medical officer with the unit, at each camp inspects the water-supply, which is almost invariably from wells, rivers or streams ; where necessary permanganates it or orders it to be boiled, filtered or otherwise sterilised ; has a sentry placed on the source of supply to prevent its pollution, and others over sources (if any) unfit for use ; he forbids the watering of animals, all bathing and washing of clothes where the water is drawn from ; allots places for bathing and washing of clothes, the watering of animals, etc. ; he inspects the food-supplies of all kinds to be issued to the troops, including the milk, and interdicts the sale and use of whatever he considers unwholesome ; selects sites for the night-soil trenches, and for the deposit and incineration of all camp refuse ; sites for the kitchens, and for transport animals ; ascertains whether there is any infectious or prevailing disease in neighbouring towns or villages, and if so, has these placed " out of bounds," and sentries posted at safe distances to prevent the troops visiting these infected places. After the first week or so only

occasional foot inspections should be necessary, and at these he also continues to note the state of the men's boots and socks, endeavours to rectify any personal causes of disease or general insanitary practices he observes; and assures himself that the camping ground is left in a clean state, and fit to be re-occupied at once by another regiment. As camping grounds in India are, as a rule, already fixed, he seldom has to select a site, but this is sometimes necessary, as on manœuvres, or when the prescribed sanitary camp for occupation during epidemic disease in cantonments has to be suddenly evacuated, or when epidemic disease occurs in the immediate neighbourhood of regular camping grounds on the march. In this case he applies his hygienic knowledge to the question of the most suitable available site.

Wide scope of medical officers' duties.—Carried out in their integrity, these duties embrace a wide field of preventive medicine, and are almost identical with those carried out by medical officers of units of the Japanese Army in the late Manchurian War.

The medical officer no longer a passive sanitary adviser.—The military medical officer of units of the present day has more power to insist on the carrying out of what he considers may favour the health of the men under his care, than was the case a few years back, and the more he is a man of action, the greater the power he will possess with commanding officers in this respect. In future he will certainly have to put aside his former *rôle* of passive adviser on sanitary questions and prevention of disease in regiments; and with a firmness and conviction in the knowledge his training and experience have given him, he must insist in no ambiguous way upon his views being carried out, and be prepared to put his ideas into action. The whole army should fully recognise that the primary function of the military medical service in peace and war is not to treat disease, but to take steps that there be as little disease as possible to encumber the Army.

Inspection of camp by medical officer before arrival of unit.—In marching with a regiment over unknown ground, except when actually in the enemy's country, the medical officer accompanied by a British officer, goes forward during the last few miles of the day's march, arriving about half an hour or so before the regiment, and inspects the camp, water-supply, food-supplies, fixes sites for latrines, for deposit of refuse, for the kitchens and the standings of transport animals.

Inspection of camp sites when marching in Brigade or Division.—When actually in a hostile country, and a party of pioneers or sanitary police cannot be sent on in advance for these duties, the regiment should be halted a mile or less from the proposed camp site or bivouac, and an advance party sent under a guard to dig temporary trenches and post sentries over water-supplies, and the regimental medical officer should always be present to superintend these operations. This can usually be done. With each regiment on the march

there is always a medical subordinate (assistant surgeon with European troops and sub-assistant surgeon with Native troops), who can attend to such cases as fainting, heat-syncope, diarrhœa, etc., during the temporary absence of the medical officer from the regiment. When marching in Brigades or Divisions the orders are :—" In the event of a long halt being contemplated during the march, a staff officer, accompanied by some mounted men, including mounted police, should always be sent on in advance of the column by the officer commanding to make arrangements. He selects, in conjunction with a medical officer, halting grounds in the neighbourhood of good water, taking adequate measures to protect the water-supply till the main body arrives "

Sanitary and other arrangements of camp to be made known to men daily.—After a march and before the troops are dismissed, water and fuel pickets are to be detailed when necessary. The places of water-supply for drinking and cooking, bathing and washing of clothes, watering of animals, the bazar, position of kitchens, latrines, refuse pits, and boundaries of unit's area, and of the district, are to be made known to the men.

Temporary latrine-trenches may be necessary.—Pending the construction of the necessary latrines, urinals, and refuse pits, temporary trenches must be at once prepared to prevent soil pollution. The construction of such latrines is, whenever possible, to be avoided ; the latrine-trenches should, wherever practicable, be ready for use when the unit arrives in camp.*

Personally one has invariably drawn up a brief set of sanitary rules to be observed by all ranks on the line of march, these being published in regimental orders for general observance. In the case of recurrent breaches of sanitary orders the special orders broken are re-published On all such occasions one has invariably obtained all possible assistance from commanding officers in carrying out hygienic measures calculated to maintain the health of their men.

Over-fatigue—meaning of.—Both during peace and in the field, but especially in the latter, over-fatigue should be avoided. It is only under critical circumstances that men should be required to make every possible physical effort to achieve a particular object. It occasionally does happen that such an effort must imperatively be made, but this is usually when the men are themselves more than eager to accomplish it. By over-fatigue we mean a condition in which the vital, physiological, and physical processes have temporarily been subjected to some strain, they have been called upon to use up their reserve of energy, and require rest for their restoration—there is, in general terms, a temporary exhaustion of natural forces. In this condition men are very prone to chill, because the normal state of the circulatory system which protects against chills, cannot be called into play ; the system is

* *Camp Sanitation* is dealt with in a special section later on.

then very susceptible to the ravages of disease-germs, because the natural resistance of the various cells which act as barriers to such germs is much lessened, if not quite suspended ; all the physiological processes—heart's action, respiration, digestion, etc.—are conducted sluggishly. Hence eating a full meal in this state is liable to be followed by acute indigestion, colic, diarrhœa, etc., because the cells of the stomach and small bowels which secrete the digestive juices are for the time being unequal to their normal task.

Recently it has been advanced as a scientific fact that the quickened pulse and respiration that occur in fatigue are due to the effects of definite toxins produced by the muscles during exertion. In response to these toxins fatigue antitoxins are created. Without knowing it, the athlete when beginning to train commences with gentle exercise during which small quantities of antibodies are developed against the toxins created ; he is thus unconsciously inoculating himself with toxins and counteracting their effects with antitoxins. He slowly increases his dose of fatigue at the same time greatly increasing his capacity to make fatigue antibodies, and so after a week's training he is able to neutralise doses of fatigue toxins that would in the untrained cause great prostration. This simple explanation as to the nature of fatigue still requires confirmation.

Conserve the energies of the troops in service.—It is the duty of every commander, from the highest to the lowest, to spare the troops under him all fatigue that can be avoided. He will do all in his power to prevent unnecessary expenditure of physical strength which invariably means loss of power.*

Necessity for and effects of sleep.—The most perfect rest the soldier on field service can get is a sufficiency of sound sleep. During sleep less blood goes to the brain and the functions of life or vital action are carried on uninteruptedly. Sleep comes naturally to the tired body and mind ; it is not necessary to search after it. By sleep we ought to be completely refreshed, and on waking in the morning feel equal to, and eager for the day's work before us. "Men must get as much rest as possible. If an early start is contemplated, no man should stir until ordered to move out. Preliminary arrangements for breakfast should be seen to overnight."†

Sanitation of units to be thorough and regular.—It is most essential that the sanitation of camps of units be carried out thoroughly each day, especially when Brigades and Divisions are passing along the same route to manœuvres or to the front in succession. Otherwise the camping grounds may become centres for the spread of disease in the Army from the beginning of a campaign. The special points demanding attention are the prevention of pollution of all water-supplies, scavengering of the surface of camps and their immediate surroundings,

* *Combined Training*, 1905, p. 24.
† *Ib.*, p. 46.

the burning of all dry refuse, and strict attention to the condition of the night-soil trenches. The encampment of the transport corps and transport animals generally, whether they be mules, camels, bullocks, donkeys or elephants, needs special watching, as they are often most objectionable (for detailed consideration of *Camp Sanitation, vide* PART II).

Cleaning of camp sites before quitting.—The rule that obtains on the march in India should be rigidly observed on field service. All camp sites, and for 120 yards around them, should be thoroughly cleaned up under the supervision of a British officer after the regiment quits it. This cleaning is necessary as the camp will be required for other troops advancing to the front and possibly also on the return march.

Sanitary responsibilities of commanding officers.—All commanding officers of units should be definitely informed as to their sanitary responsibilities in connection with their own regiments. This is to a certain extent now laid down in Regulations.

Distribution of sanitary work in units.—The commanding officer should define the limits of the regimental camp for the sanitation of which each of his officers is responsible.*

Position of supply and other depots.—When marching or camping in Brigades or Divisions, officers commanding units are to be informed of any localities or depôts outside his own area on which he may draw for water, fuel, straw and other supplies. In each district a place for a market will, if necessary, be selected, and a tariff of prices arranged. All persons coming into the district to sell articles of any kind must be confined to this place.†

Period of inertia.—Periods of inertia, which may last days or weeks, are the times when men feel the hardships of field service most, and it is at this time that officers can do much to relieve the monotony by organising games, athletic competitions, mimic warfare, devising interesting camp defence work, etc., to keep the men employed.

The main diseases to be on guard against on the march are *enteric fever*, which arises from contaminated water and milk, soil infection, fly infection and infection through "carriers"; dysentery and diarrhœa from specifically contaminated water and soil; food infection from flies, etc., but greatly predisposed to by defective food and imperfect cooking, abdominal chills; attacks of malarial fever from chill in men already infected with malarial parasites, attacks of catarrh, bronchitis and pneumonia, all specially predisposed to by chill, remaining in wet and sweaty clothes, especially in a wind; heat-syncope from the effects of the actinic rays of the sun; ordinary attacks of fainting from

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* *Combined Training*, 1905, p. 40.
† *Ib.*, p. 40.

temporary overstrain. There is always the possibility of cholera occurring from specifically contaminated water, milk or food in districts where this disease is prevalent; and plague from infection in districts where it is either endemic or epidemic.

In is for the medical officer or sanitary officer to make minute inquiries of the local village or town authorities as to whether there is any form of infectious disease in the village, town, or neighbourhood of the proposed camp and advise as to precautionary measures necessary.

C.—Preparation for the Advance to the Frontier.

Fitness for field service.—It is presumed that every officer, non-commissioned officer, and man entering on a campaign, is thoroughly fit to undergo the hardships, privations and exposure necessarily associated with fighting.

What fitness for fighting means.—Fitness in this respect signifies that during times of peace the physical and intellectual processes are being constantly enriched, the state of health is being maintained at the highest possible standard in all men, the powers of endurance progressively enhanced, the stamina improved, the capacity to resist disease-causes rendered greater, and the actual fighting power of the individual brought to its highest pitch of perfection.

Medical examination of all ranks as to fitness for field service.—Every officer, non-commissioned officer, man and follower must, by regulation, be subjected to a medical examination as to his fitness for field service, before being allowed to proceed to the front.

Medical examination of units.—For this inspection the men should parade without coats, with their neck and chests bare, their shirt sleeves rolled up to the elbows, without boots and socks, and with the trousers folded up to the knees. The medical officer passes down the front and rear of one company at a time, dismisses it when finished, and passes on to the next company.

In carrying out this medical inspection of a regiment the medical history sheets, arranged in companies, troops, or batteries, should accompany the medical officer, so that in all doubtful cases he may be able to refer to them at once. This inspection should not be hurried. A note-book should be used, and all men about whose fitness the medical officer is doubtful should be fallen out and grouped together, for more detailed examination subsequently.

Chief conditions calling for rejection.—Amongst the diseases and conditions to which the inspecting medical officer should direct special attention are—presence or absence of fever, the hand being applied to the exposed chest of all men; indications of malarial infection anæmia, enlarged spleen; syphilitic rashes; skin eruptions generally; the presence of emaciation; the condition of the eyes,

which is significant to the medical officer in many maladies; and the state of the gums, mouth, and teeth should receive particular attention.

Malarial infection.—Regarding malarial infection, the medical officer knows that every man who has suffered from recent malarial infection is an abiding source of danger to his comrades in the presence of malaria-bearing anophelines. It may be possible to eradicate the infection before reaching the base of operations—it will be a matter of personal judgment on the part of the medical officer whether such a man be allowed to go or not. He will, however, not forget that men are eager for field service, and that they will dissemble even with an acute disease on them on this occasion. During such inspections one has eliminated cases of malarial fever with anæmia and enlarged spleen, secondary syphilitic eruptions, and even tuberculosis of the lungs.

Exclusion of venereal cases.—No man with any existing manifestations of venereal disease should accompany the force into the field, and with all European, and most Native troops, especially unmarried Gurkhas and Punjabis, a venereal inspection is necessary. Opportunities for acquiring such disease on the march to the front are limited, but not absent, especially on our North-East Frontier, in Burma, and some places on the British side of the North-West Frontier. Where their acquisition is possible, the preventive measures are essentially disciplinary, and rest with commanding officers of regiments—he will "place out of bounds" all localities in which venereal disease may be acquired. Amongst European troops in particular a rigid venereal inspection is an imperative necessity. On several of our Frontier campaigns venereal disease has appeared where opportunities for contagion *en route* could legitimately be excluded. In these it was either present when they left their stations, or developed soon afterwards.

Preliminary medical examination of units recommended.—When possible, a fortnight before the final medical inspection, it is advisable for the regimental medical officer to make a preliminary examination of all men and followers. This early inspection should embrace a thorough examination of the feet for abrasions, shoe-bites, corns, in-grown toe nails, etc., to get these cured before the march to the front begins. He should give instructions regarding the way to keep the feet hard, and how to keep the boots sufficiently supple to prevent injurious friction. Shoe blisters are easily remedied by passing a threaded needle through them, and keeping the thread in 12 hours or so. For the first week after the beginning of the march to the front, it is advisable to hold a daily foot inspection, and to treat all cases not likely to be well in a day or so.

The medical officer should assure himself that the men are provided with all the articles of field kit laid down in the Regulations or sanctioned for the special campaign to be entered on. He is, of course,

not responsible that they are so provided, but it will save him much labour later on, if he finds, for instance, that the cholera belt has been omitted. He will ascertain that they all have water-bottles capable of containing at least $1\frac{1}{2}$ pints—a quart would be better—and order the water-bottles to be scalded with boiling water twice a week. When on the march, he should every now and then feel some of the water-bottles to see whether they are full—some men will avoid, when possible, carrying two pounds extra weight. He should specially inquire as to how many shirts, pairs of socks and boots the men have. He should insist on the men wearing their cholera belts at night.

Medical inspection of followers.—Medical officers should exercise special care in the inspection of all classes of both public and private *followers* for field service, particularly as regards their physique and the existence of malarial fever or its effects. Men of comparatively advanced years should invariably be rejected. Followers not having had the physical training of the soldier, are far more liable to break down under the hardships and physical strain of a campaign. Those not really fit break down readily, and most of them being by nature helpless, resourceless, and improvident, become early victims to disease, and a great incumbrance to the Army. In his inspection the medical officer should bear in mind the nature of the climate, and the possible extremes of temperature that may occur during a prolonged campaign. Apart from the question of expense entailed in selecting unsuitable followers, they drain the hospitals and strain the resources of our ambulance transport. It is also necessary to see that all public followers are provided with the regulation scale of clothing and blankets. In laying down this scale, the time of the year and the climate to be endured should be considered by those authorising their issue. Untold hardships have been witnessed by inattention to, or want of, forethought regarding this simple duty.

Issue of first field dressing.—Medical officers of corps will see that combatants of all ranks are provided with a first field dressing before entering on a campaign and warn all ranks of the importance of keeping it scrupulously clean and safe. This applies to every combatant of all branches entering the field—the timely application of a first field dressing frequently saves a man's life. The first field dressing of the present day is the best that can be given the soldier—it behoves him to make the best use of it. Applied to a wound in the absence of expert aid, it affords the best possible chance of that wound doing well, of the patient recovering and returning to fight again at the earliest possible date.

Instruction in first aid to the wounded.—The medical officer will have carried out the Regulations in regard to the teaching of all British officers, Native officers, non-commissioned officers the use of the first field dressing. The more important parts of this training are the impromptu methods of stopping hæmorrhage from wounds, and the maintenance of cleanliness in wounds. The bullet wound of modern small

arms is aseptic; it is for the wounded soldier and those attending him to keep it so. The less wounds (and injuries of all kinds) are handled, except to remove visible impurities such as pieces of cloth, washing off of gross visible dirt by an antiseptic solution or sterilised water, the better chance the wound and patient have.

Stretcher drill.—He will also have eight men per company and all the band trained in stretcher drill, and in the carrying of sick and wounded. The medical officer as part of his duties in peace times directs and supervises the stretcher and ambulance drill laid down in Regulations.

Vaccination inspection.—Every man should be protected from small-pox by vaccination or re-vaccination. In the Indian Army this is to a large extent assured by the annual vaccination inspection; but there are always, especially amongst followers, a certain number who escape or evade this protection. To the timely circular issued in August 1905 in the Northern Command, with regard to the vaccination of all unprotected men taking part in the Rawalpindi manœuvres in December 1905, was due our escape from what might have been a widespread epidemic of that terrible malady. On that occasion the disease was actually brought into Rawalpindi by a certain number of transport and other followers.

Medical and scientific literature of seat of campaign to be read by all medical officers.—Principal medical officers, senior medical officers, sanitary officers and all medical officers of units, should endeavour to familiarise themselves with all available knowledge regarding the nature of the country, and all conditions in any way liable to effect the health of the force; its meteorology—temperature, its mean diurnal variation, its extremes, humidity, rainfall; its geology, especially as regards its effects on camping grounds and the various sources of water-supply; the water-supply itself—quality, quantity, necessity for purification; resources as regards fresh animal and vegetable foods and milk; the special diseases of the country; and the medical histories of former campaigns in that region if there have been any—should be carefully gone into. There are now comparatively few parts of our Indian Frontier regarding which information on the above points may not be acquired from previous records or works of travel, and exceedingly few regarding which no knowledge is to be had.

Selection of season of year for expeditions.—As far as practicable the best time of the year will naturally be chosen for campaigns; but military exigencies do not always permit of this, and in a long campaign, such as the Third Burma War (1885—87) almost every variety of weather has to be endured. One can recall occasions in Burma in 1887, when in May and June, we had to make various short *dours*, usually lasting 14 to 16 hours, when the temperature in the *poonghi kyoungs* we occupied was 120°F. In Thibet there was the

other extreme of many degrees below zero, plus the effects of rarified air at heights varying from 12,000 to 16,000 feet. In a short expedition up the Khanki Valley to the Lozakka Pass to recover rifles and fines, early in December (before Karuppa was evacuated), we had 14 degrees of frost for the two consecutive nights, in which we bivouacked. We have still fresh in our memories the march of the 35th Sikhs to the relief of Malakand from Nowshera, with its dreadful roll of cases of heat apoplexy.

Move to front by rail, river, sea or marching.—The move to the front will usually be partly by rail and partly by marches. It may, however, as in the Mishmi and Bhotan Expeditions, be by rail, river and marches, or as in the Third Burma War (1886-77) by rail, sea, river and marches.

PART II.

GENERAL HYGIENE.

WATER-SUPPLY.

A.—Sources of Water.

Importance of the quality of drinking water.—The quality of the water drunk by the soldier in cantonments, on the march, on manœuvres and in the field is one of the chief determining factors in regard to the state of his health. The introduction of public water-works into all our large stations has greatly contributed to the improvement that has occurred in the health of troops during peace times. There is abundant evidence to show that the invariable consumption of boiled sterilised water by the Japanese throughout their Manchurian Campaign was the main reason of their comparative exemption from diseases caused by unwholesome and impure water. Such diseases form a large proportion of the preventable maladies of the soldier on field service. To enable us to properly understand the various ways in which an impure contaminated water may affect the health of troops in the field, and the measures usually adopted to purify all water issued to them, it would be profitable to consider the sources of supply, the quality of the water from these sources, and the various ways they are polluted, the different methods of purifying water for the use of troops in cantonments, on the march, in standing camps and on field service, and lastly the general methods employed in examining water as to its purity or otherwise.

Use of unauthorised water to be strictly interdicted.—While referring to water here, one would repeat that all soldiers, both in peace and on field service, should be strictly forbidden to drink unauthorised water. In our future campaigns all water not directly from reliable springs will probably be boiled, or filtered, or both—that is, sterilised. On field service only such sterilised water should be consumed. Whenever authorised water is available the water-bottle should be filled. This boiled or sterilised water must, however, be kept sterile. Sterilised water in dirty water-bottles soon breeds germs. The water-bottle must always be kept clean, by scalding with boiling water two or three times a week. One has repeatedly, in examining water-bottles, found the angles and joints in a very dirty state. The present water-bottle in use in India cannot be thoroughly cleaned and inspected. Reference is made to this later on in the section on *Equipment of the Soldier*.

Soldier to be trained to control his thirst.—Soldiers should be methodically trained to keep under control the desire to imbibe large quantities of water or other liquids when they feel thirsty; they should be disciplined to this during manœuvres, on field days and route marches. Such restriction is very necessary, and particularly so in the young soldier, in whom the habit of deluging himself with liquid is easily acquired, but it is in him also easy to prevent before such a habit is developed. Where soldiers are thus trained, they resist the yearning to drink the first water they come across on field service. From the beginning of his military career then, the soldier should train himself not to give way to thirst. The drinking of large quantities of fluid is mainly habit. To yield to the inclination to completely assuage thirst grows—it can be kept in check. Ability to control thirst is one of the tests of endurance, therefore the sensation of thirst should be kept thoroughly in check. Frequently, simply rinsing out the mouth and back of the throat with water will remove the desire to drink. One cannot condemn with sufficient emphasis the attitude that officers used to adopt a few years back, to the effect that it is useless to attempt to stop men drinking water anywhere and anyhow, under the conditions of field service. One knows from experience with many regiments that this can be done. The soldier if he is taught how to take care of his health will do so, and he will certainly drink pure water when it is provided in sufficient quantity in preference to water of uncertain quality.

Water is a compound of two gases, oxygen and hydrogen, united in the proportion of 1 volume of the former and 2 volumes of the latter, 1 atom of the former to 2 atoms of the latter, or 16 parts by weight of oxygen and 2 parts by weight of hydrogen. It can be formed artificially by mixing oxygen and hydrogen, and applying a light when the two gases combine with a loud explosion. When water at the ordinary temperature is heated it expands, and at 212° F. at sea level, it boils, being converted into steam. At the tops of mountains water boils at a much lower temperature. Its boiling point is raised when solid bodies are dissolved in it. When cooled, water contracts until the temperature sinks to 39·2 F.; but if cooled to a still lower temperature, it begins to expand (thus forming a remarkable exception to the general rule), and it continues to expand until the temperature sinks to 32° F. (0° Cent.), when it freezes or solidifies and is converted into ice. It is thus obvious that a given weight of water will occupy the least bulk when its temperature is 39·2° F., and this is termed the *point of maximum density*. Its specific gravity at 39·2° F. is 1 or unity, the specific gravity of solid and liquid bodies being standardised by it. Ice therefore floats in water. Water is the greatest solvent known. It dissolves all known gases and the majority of solids, in this being helped by the gases dissolved in it. It has a high capacity for heat, but is a bad conductor of heat. Water forms about 66 or 67 per cent. of the body-weight; the blood contains 79 per cent. of water, even bone contains 10 per cent. of water. One gallon of water at 60° F. weighs exactly 10 pounds; 6·23 gallons of water occupy 1 cubic foot. Pure water is a colourless, transparent, tasteless and inodorous fluid.

General sources of water.—The natural sources of water-supply are rivers, streams, lakes and springs, but the general sources of all fresh waters are the seas and oceans. Nature effects a distillation for us. From the ocean the heat of the sun effects a vaporisation of water into the air. A vast quantity of water is drawn up from the sea in this way in the form of vapour, which mixes with the air. The wind blows this hot and moist air to a cooler place. This results in the formation of clouds and a fall of rain. Air at any particular temperature can only hold a certain quantity of water in the form of vapour. In the invisible form water is conveyed by the air over the land, re-condensation takes place, and it is

precipitated as snow, hail, and rain, but chiefly as rain. On reaching the surface of the earth the rain is disposed of in various ways: a portion is evaporated, another portion flows in the direction of the inclination of the surface, and a third portion percolates into the soil. The amount of rain that evaporates depends upon the temperature and degree of humidity of the air—the higher the temperature and the drier the air, the greater the evaporation. When the inclination of the surface is but slight and the soil very permeable, a large part of the rain sinks into the earth; but if the soil is not porous, the greater part of the unevaporated water flows down the incline. This is the portion that helps to swell streams and rivers. A small share of the percolated rain-water is absorbed by the roots of trees, grasses and vegetation generally, but most of this is subsequently evaporated from green leaves. When it rains heavily, the greater part of the water finds its way to the large rivers, and finally into the seas and oceans once more, after subserving the great offices of supporting animal and vegetable life. A constant circulation of water is taking place between the earth, air, and the ocean.

Quantity of water required.—The average quantity of water required for each person will vary according to the extent to which the processes enumerated below are carried on. If the sewage of a town is removed by underground pipes, a large quantity of water per head of the population will be required to keep the sewers well flushed and clean. The *quantity of water required for different purposes* will also vary in different places, and amongst different classes of people.

The quantity of water required for *drinking* purposes is about *half an ounce for each pound weight of the body*. In less general terms we may state that an adult man requires from 75 to 80 ounces of water a day. Of this quantity about one-third is contained in the so-called solid food. To prepare this solid food and fit it for consumption and assimilation* water is added, so that on the whole, only about one-half of the water is left to be taken in the liquid form. Owing to the free action of the skin (sweating) in India in the hot weather, a larger quantity than that given is required. Of the water taken in the food and as drink, about 50 ounces is got rid of by the kidneys, about 18 ounces by the skin, as perspiration, and the remainder by the lungs. In the hot weather, however, a great deal more is given off by the skin and less by the kidneys. During hard physical exercise or labour, we perspire a great deal more and give off more watery vapour from the lungs than at other times. The kidneys, on the other hand, secrete less water under these circumstances. If the air is dry, an increased amount of water is given off by the skin and lungs. In these last two cases (increased exercise and dryness of the air), it is through the heat lost by evaporation that the body is kept from becoming too warm, and the normal temperature is maintained.

In a large cantonment with a good and abundant supply of water, the following is the basis on which the amount of water per head is calculated :—

	Gallons.
For Cooking	·7
Drinking	·3
Ablution	5·0
Domestic uses :	
House cleansing	3·0
Laundry	3·0
Baths	4·0
Waste	3·0
Municipal	5 0
Total ...	24·0

* *Assimilation* is that process in the animal economy by which the ingredients of the food are converted into blood, and by which the nutritive matter contained in the blood is transformed into living parts of the various organs and tissues of the body.

In the *King's Regulations*, 1908, section 1037, the quantity laid down is 20 gallons for an adult and 10 gallons for a child.

There are some cantonments, in which the small quantity of water provided gives rise to a certain amount of hardship. Deficiency in quantity leads to disease from dirt.

During camp life, roughly speaking, each man requires for drinking purposes four pints a day, for drinking and cooking four quarts, and for drinking, cooking and washing, from three to four gallons. *Combined Training*, p. 45, says : "A daily average of one gallon per man is sufficient for drinking and cooking purposes. A horse, bullock or mule drinks about 1½ gallons at a time. In standing camps, an average allowance of 5 gallons should be given for a man and 10 gallons for a horse."

Special sources of water.—As special sources of water in India we have :—

(1) *Rivers, streams,* and *springs.*

(2) *Wells,* superficial and deep.

(3) *Tanks,* large and small, natural (lakes) and artificial.

(4) *Ponds, ditches, effluent from irrigated land,* and *marsh water.*

(5) Canals.

(6) Public water-works with their storage reservoirs, water-pipes, stand-pipes are now constructed in many towns, and practically all cantonments in India.

In general terms it may be stated that all of these waters except the last-named and springs, are more or less impure, and that without previous boiling and filtration are unfit for drinking purposes. All are subject to various forms of pollution. It is a safe rule to assume that in India all water from natural sources is impure and unsafe to use for drinking purposes unless it is previously purified.

Classification of waters.—The following *classification of waters* shows roughly the comparative merits, relative degree of wholesomeness, palatability, and general fitness for drinking and cooking purposes, of water from different sources :—

Wholesome ...	1. Spring water	Very palatable.
	2. Deep well water	
Wholesome ...	3. Upland surface water	Moderately palatable.
Suspicious ...	4. Stored rain-water...	
	5. Surface water from cultivated land ...	Palatable.
Dangerous ...	6. River water to which sewage gains access.	
	7. Shallow well-water	

Water of the greatest purity is got from uncultivated and barren uplands.

River water.—When people along our Indian frontiers begin to build a town they select a site in proximity to a perennial water-supply. The banks of a river are frequently chosen. In gathering together in communities, large or small, they pollute the river water. If many such towns or villages are on the banks of a river, the water arriving at the lowest of them will be poisoned to some degree. We need scarcely dwell on the fact that when large masses of people are congregated in towns and villages, a sort of artificial existence arises, in which the collective habits of the community affect the individual, and that in accordance with nature of these habits, *air*, *soil*, and the *water* of the soil are variously contaminated. These three factors (air, soil, and water) are so correlated that they react upon one another. An impure soil means that all shallow wells sunk in it will contain impure water. In this country we frequently see the people using the margins of rivers as a latrine, subsequently washing themselves in its water. Were contamination from human excremental matter to be an absent factor, the water of most rivers would be fit for use after filtration. Contamination from human excreta is the worst form of pollution to which any water-supply can be subjected, and this fact cannot be too widely known. The excreta may contain the germs of such diseases as enteric fever, dysentery, infective diarrhœa, cholera, etc. The possibility of such specific contamination of water-supply is a genuine danger to all Armies in the field.

People wash clothes in rivers. We know that these soiled clothes contain some of the waste matters from the body, and may have just been worn by patients suffering from infectious or contagious disorders—dysentery, diarrhœa, enteric fever or even cholera, for instance. It is clear that, if the germs of the disease are washed into the water, the inhabitants lower down the river using it are liable to

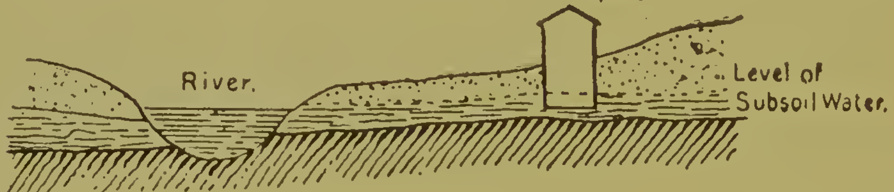

FIG. 3.—Diagram showing contamination of river by subsoil water.

be affected by such germs. If dhobies *must* wash clothes in rivers, they should have a part of the river allotted to them, situated below the habitations of the people. The bodies of people who have died of cholera, dysentery, diarrhœa, etc., are often thrown into rivers. Crowds of human beings may be seen spitting into river water and subsequently drinking it. Cattle, horses, elephants, and other animals, are taken to the river to be washed, their droppings and urine pollute the water, as do also the foul matters washed off the surface of their bodies.

In small rivers and streamlets forming water-supplies these practices are so injurious to health as to be a matter of danger to life itself. All the *nullahs* and ditches around inhabited places during the dry seasons are used as latrines, the consequence being that the first outburst of the rains washes into the rivers the accumulated refuse of the previous dry period, together with the decaying vegetable matter that abounds in such places. We have in more than one town in this country seen natural water channels connected with main drains emptying their foul contents into rivers, and other towns in which the drains have been specially constructed to convey the drainage into rivers.

During the monsoons rivers look muddy. At that period they flow with greater rapidity, and stir up the solid matters from the bottom. The rain-water conveys into the rivers a considerable quantity of earth and organic matter. But a muddy water may not be undrinkable. By letting it stand for a time, the mud gradually precipitates. We can hurry the process of this deposit in many ways, as by the addition of a little alum.

The water of large rivers is, as a rule, purer than that of smaller ones. In large rivers, the poisons are in a more dilute form, the flow is more rapid, and the

water mixes with a greater quantity of air—the oxygen of the air acting as a purfying agent.

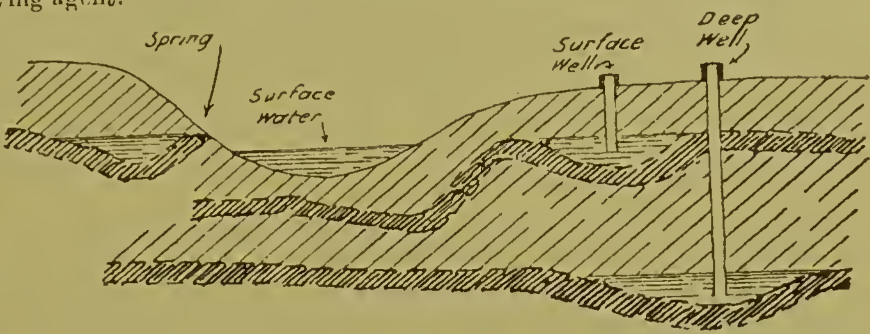

FIG. 4.—Diagram illustrating some common sources of water.

The smaller the stream, the more jealously should it be watched, and the more carefully should it be protected from contamination. Drying up rivers and streams occasionally become the means of the propagation of disease from their having been infected at a higher level.

Streams close to their sources, passing through land not cultivated and devoid of human dwellings, are good sources of water-supply; but streams and rivers passing through cultivated valleys, with towns and villages on their bank, furnish water which must invariably be regarded as suspicious in quality, and, in point of fact, such waters are often dangerously polluted.

Allotment of places for drinking water, bathing, washing of clothes, and watering of animals.—When the supply is from a river or stream, the highest convenient point from the camp should be fixed for drinking and cooking water, below this a site for watering of transport animals, lower still one for bathing and washing clothes.

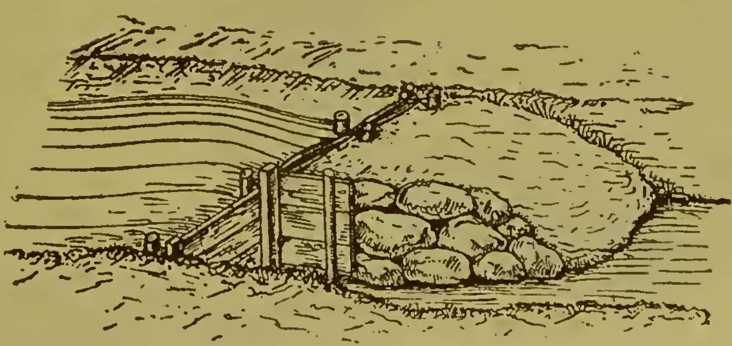

FIG. 5.—Method of forming reservoir for camp

Yield of a stream.—The volume of flow or discharge of a stream of water is usually expressed in units of volume per unit of time. A rough estimate of the yield of a stream may be measured as follows :—Select 12 or 15 yards of the stream, where the channel is fairly uniform

and there are no eddies. Take the breadth and average depth in feet in three or four places. Drop in a chip of wood and find the time it takes to travel say 30 feet, this gives the velocity in feet per second. Four-fifths of this will give the mean velocity, and this multiplied by the sectional area in square feet will give the yield per second in cubical feet of water, remembering that a cubic foot of water is equal to $6\frac{1}{4}$ gallons (about $62\frac{1}{2}$lbs).

Patrolling by mounted men will often be necessary for some distance above the spot where the drinking water is drawn. The water-supply will be marked by flags by the advanced party—*white* for drinking water, *blue* for watering of animals, *red* for washing and bathing. If the camp has to be drained of rain and it is close to a stream yielding the water-supply of the troops, the outlets of the camp drains should, where practicable, be below the site for bathing and washing purposes.

Casks sunk in the bed of a stream afford convenient dipping places from which to draw water. It is worth mentioning that *deep* wells sunk near a river frequently yield exceedingly wholesome water.

Springs and spring water.—Springs may be divided into *land springs* and *main springs*; the former often occur in surface depressions touching the subsoil water, and usually when the underground water reaches its lower levels such springs run dry. Being supplied by ground water they may be very impure. "Main springs are generally good as they act as the main outlets of geological strata, but occasionally they are doubtful sources of supply and great care is necessary to investigate their immediate neighbourhood from surface derived impurities."

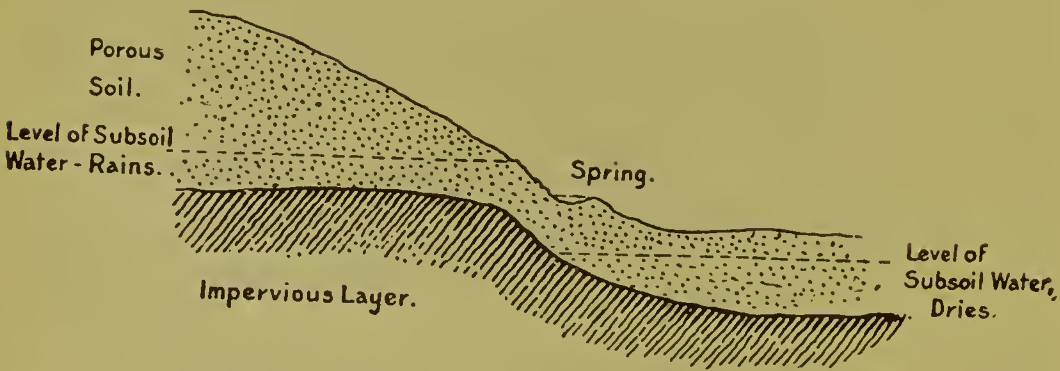

FIG. 6.—Intermittent spring.

Spring water is as a rule wholesome though it is occasionally hard. It is clear and sparkling from the dissolved carbonic acid gas it contains. That from deep springs is the best of all potable waters,

being a naturally filtered water. It is only when springs are superficial, or within reach of contamination, that there need be any apprehension of their use causing disease Fountains are imitations of natural springs Just as water rushes up springs from any artificial fountain that is supplied through pipes from a reservoir at a higher level, so water naturally springs from any crevice or porous spot in the ground that is supplied through the underground channels with rain-water which falls on a higher level, no matter how far distant that higher gathering ground may be. A *spring* of this kind may be met at or near the surface of the ground, or at a considerable depth; the same physical law is at work here as in the case of artesian wells. In *quality*, the water of springs is much the same as that of deep wells, and it contains usually the same kind of gases and solids. Spring water usually contains a certain amount of mineral matter. This mineral matter is obtained from the soil by water permeating a soil

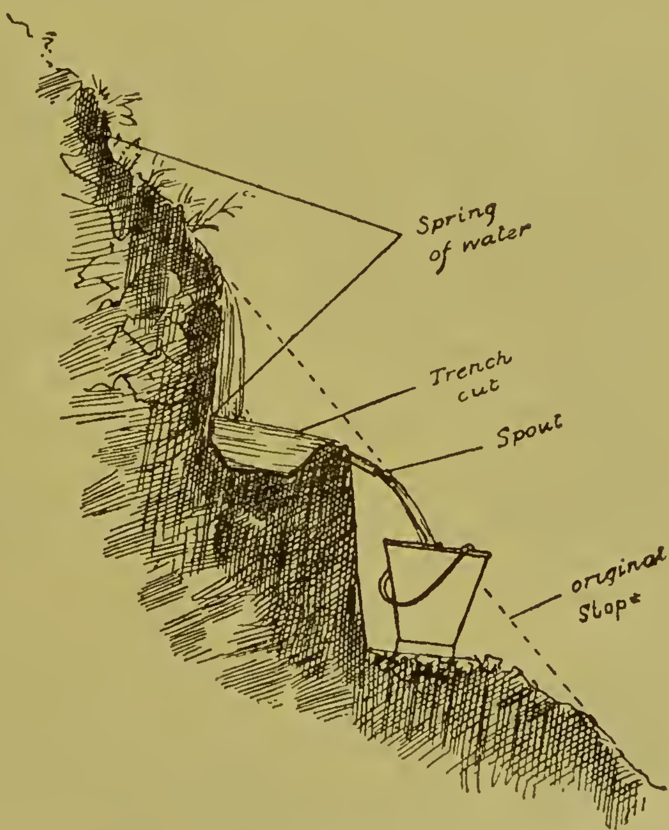

FIG. 7.—Diagram showing an arrangement for collecting water from a spring.

containing much carbonic acid gas. This gas dissolved in the water percolating with it through the soil, dissolves out certain amounts of alkaline earths and metals, which appear in solution (as *bicarbonates* of lime and magnesia chiefly). Spring water contains much carbonic acid and but little oxygen, the former gas giving to such water its

fresh, brisk taste. Springs are usually purer than other supplies, because they are from a deeper source in the soil the water has been naturally filtered ; they are also farther from sources of contamination

Spring supply to be opened up and fenced in. – If the water-supply is from springs each spring should be opened up and surrounded by a low puddled clay wall to keep out surface water. Casks or cylinders made of brushwood like gabions make good linings for springs. After being placed, puddled clay may be worked down between the banks and the casks or cylinders. The overflow may be received into a succession of casks or half barrels (which may with advantage have their insides charred) let into the ground close together, the overflow from the first passing into the second and so on, or deep narrow tanks with puddled sides may be constructed to catch the overflow.*

Well-water.—There are three varieties of wells—*shallow, deep* and *artesian.*

Shallow wells.—Shallow wells are those which drain the underground water which rests on the first impermeable stratum of the subsoil. Shallow wells may thus be very superficial, only a few feet, or 40 or 50 feet or more below the surface. As water is drawn from them, the area drained extends in all directions, and the larger the amount of water drawn, the greater the area drained. The well thus forms a cone having its apex at the surface of the well-water, and its base on the surface of the underground water. The extent of area thus drained varies with the nature of the soil. When the soil is gravelly or sandy, the radius of the area drained may be as much as 200 times the depth of the well ; when it consists of fine sand, the radius may not be more than 10 or 15 times the depth of the well.

Deep wells.—A *deep well* is one that is sunk through an impermeable stratum, getting its supply from the underground water-bearing layer of soil. Its depth may vary from 30 to 50 feet from the surface, but it may be considerably deeper, from 100 to 250 feet or more. The underground stratum beneath which the water is found is usually stiff clay or rock. Water from such a source is, as a rule, pure and wholesome, and free from fouling by organic matter.

The quality of deep well water varies, therefore, in accordance with the nature of the geological formations through which the water flows before reaching the well. Local experience is generally sufficient to indicate what the quality of the water ought to be. Deep well-water is usually "harder" than river water. The hardness is chiefly due to lime salts, especially the carbonate, held in solution by excess of carbonic acid.

We cannot lay down a rule that all shallow or surface wells contain impure, and all deep wells pure, water. In exceptional cases shallow

* *Manual of Military Engineering*, 1905. Such springs as a rule can only supply comparatively small communities and usually for only a limited period of the year.

wells may contain wholesome water, and deep wells polluted water; but the reverse is much more likely to be the case.

Artesian wells.—Artesian wells are made by boring into the ground until a layer of water is come upon, which layer has in some other place a much higher level. The water is forced up and spouts out as an artificial spring. Water from such springs is generally pure and wholesome, but lies so deep that it is too costly to bore for it. Such wells have not as yet, except in a few instances, served any practical purpose in Indian military hygiene.

Pollution of shallow wells.—If a shallow well has a depth of, say, 30 feet, the diameter of the base of the cone drained may be anything up to 200 yards or more, and any impurities contained in the soil in the supplying area will gradually reach the water. If, for instance, a neighbouring cesspool or a drain-pipe empties itself into this area, its contents may reach the well; if dead bodies with disease germs are buried in the line of supply, the germs may find their way to the water, and the same occurs with regard to the

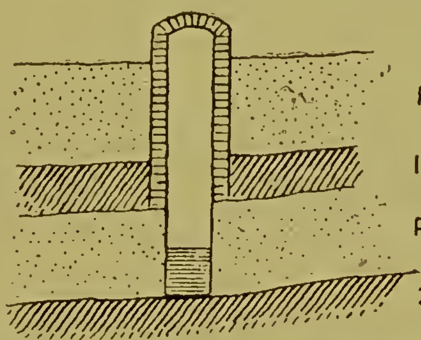

Fig. 8—Deep well.

products of all decaying organic matter, vegetable or animal, within this area.

In addition to the foregoing, pollution of shallow wells may occur from privy pits of all kinds, manure heaps, and collections

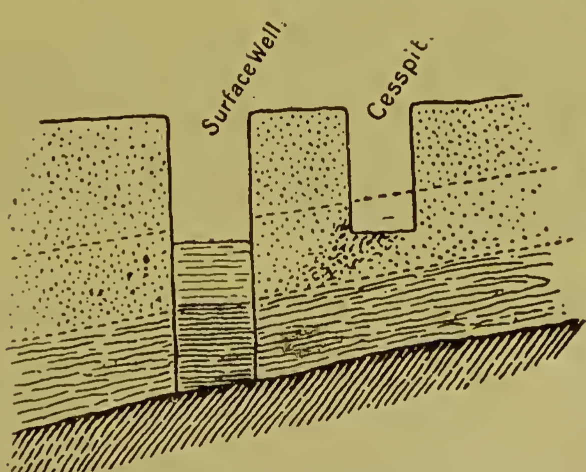

Fig. 9.—Diagram showing contamination of surface well by cesspit.

of refuse house waters in *katcha* excavations of the soil within the area drained—these are always dangerous possible sources of pollution. One has several times found cesspools in houses draining directly into the house well, and in two such cases epidemics of cholera were started in this way. The soil around the mouth of the well may also be contaminated, and if the well is not protected above may directly pollute it.

Many superficial wells are always impure and become more so during the dry weather. These are rendered less so after the rains when the sources of pollution are diluted. On the other hand, heavy rains may cause the ground water to rise and reach sources of pollution that were absent previously.

The inflow of surface drainage water is one of the chief sources of pollution of wells. This *surface drainage* is the rain, house-refuse liquids, etc., that reach the surface of the ground and pass along the natural line of drainage without penetrating the soil. This surface water in passing over filthy ground carries with it many forms of impurity.

In the case of some superficial wells situated in the heart of populous localities, the ground around is so saturated with organic impurities that any material improvement of the quality of the water they yield is practically impossible; the soil around such a well will continue to add its quota of polluting material so long as the well exists.

Shallow wells in their ordinary state afford an excellent breeding place for germs. As above remarked these wells are supplied by the ground water, and it is supposed by some authorities that the height of the level of this ground water has an important bearing on the prevalence of certain diseases, especially typhoid fever and cholera, at certain seasons. Serious contamination of shallow wells is seldom absent.

That a well is popular as a source of drinking water is no guarantee as to its purity. The water of wells containing organic matter undergoing decomposition frequently has a peculiar but not altogether unpleasant taste: further, such a water has a slightly sparkling appearance, due to the carbonic acid gas that is set free by the decaying organic matter, thus giving the water the specious characters of a good water.

The water of all wells and springs is derived from rain. The rain-water percolates through various surface soils until stopped by an impermeable stratum of clay or a layer of rock. In the impermeable strata the water collects, rendering them water-logged up to a certain level, the line of this water-logging corresponding with the lowest level of the natural outlet through which the underground water is escaping to rivers, streams, etc. Beneath the soil we have an extensive

subterranean reservoir, and it is this reservoir that is tapped when a deep well is sunk through stiff clay or rock.

From the foregoing statements with regard to wells we see that the water they yield may be good or bad. If a well is deep, the water it supplies is probably good, provided that the flow of surface drainage and subsoil water into it is prevented. On the other hand a shallow well, as a rule, contains impure water.

On many parts of our Frontiers, and on the march to reach them, we will have to rely on wells for our water-supply. This general use of well-water, together with the fact that the water of wells is, in a large number of cases impure and unwholesome, render a consideration of this form of water-supply very important. We have alluded to the habits of the people as being instrumental in effecting pollution of water-sources generally. These habits act more banefully on the limited quantity of water contained in wells. The water of some of the superficial wells one has analysed was really a form of dilute sewage.

Before sinking a deep well, engineers ascertain the direction of the flow of the subsoil water so as to carry out the sinking in such a way as to cut off, if possible, the access of the subsoil water. If any difficulty is experienced in ascertaining the direction of the flow of the subsoil water, he is guided by the general rule that it flows with the natural inclination of the ground.

A well that has supplied water for years without producing any evil effects may suddenly become a source of epidemic disease. Especially is this liable to occur after a case of cholera or enteric fever is imported into the town or village, and when by accident some of the excreta from a patient reach the well in some way, directly from the mouth of the well through specifically polluted utensils, or indirectly through the subsoil water supplying the well. Unprotected shallow wells are a cause of a large amount of sickness in towns and villages not provided with a public water-supply.

Protection of wells.—All wells should be steined* down to the surface of the water, and when this has not been done from the first, they should be protected by an impermeable lining for a depth of 15 feet from the surface at least. All wells, especially shallow wells, would be greatly improved by such steining. This steining should consist of a compact wall of stones or brick, covered with a smooth lining of concrete or hydraulic cement, so as to prevent subsoil water above this height finding its way to the water of the well. If the surface water then does sink below this lining, it is at least filtered through 15 feet of soil before entering the well. When constructing *new wells*, the steining in shallow wells should reach to below the level of the water, and in deep wells below the first impermeable stratum, which ensures a fair depth of filtration of the water through the soil.

In making the well, horizontal iron bars, a foot or so long, may be let into the walls one above the other from the mouth of the well down to the water in the form of a ladder to facilitate periodical cleaning of silt and repairs; incidentally this also provides means of escape for any one falling into the well.

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* *Steining* is the technical term used by engineers for the lining of wells with some impermeable material, such as hydraulic cement, etc.

The bottoms of all wells should be cleared of silt at the end of the hot weather yearly; at this time the water is low and the work easier. This is done annually in all wells of our Indian camping grounds, and wells on the usual marching routes. At the same time any repairs to the lining wall required should be carried out, and the removal of any plants that have grown in the wall, or roots that have penetrated, should be effected. The well should not be used for a few days after this cleaning, to allow of subsidence of solid matter aused by the inrush of water. Without seeing and smelling the material that is removed from the bottom of some shallow wells, it is difficult to imagine that such filth could be contained in them. Yet millions of people are daily drinking part of this disgusting material in a dilute form, because they do not or cannot get their water from a source that is protected from pollution due to their unclean habits and to surface drainage.

Wells known to contain wholesome drinking water should be carefully guarded and set apart as such; others containing less pure water should be allotted for bathing, washing of clothes, watering of animals and roads, and for trade and other purposes. No washing of clothes or bathing should ever be permitted in the vicinity of drinking water wells. Condemned wells should be filled up or permanently covered. When at all accessible notices should be posted on them to the effect that it is dangerous to drink the water.

Drinking water wells should be as centrally situated as practicable to be easy of access, so that there is no excuse for using impure water

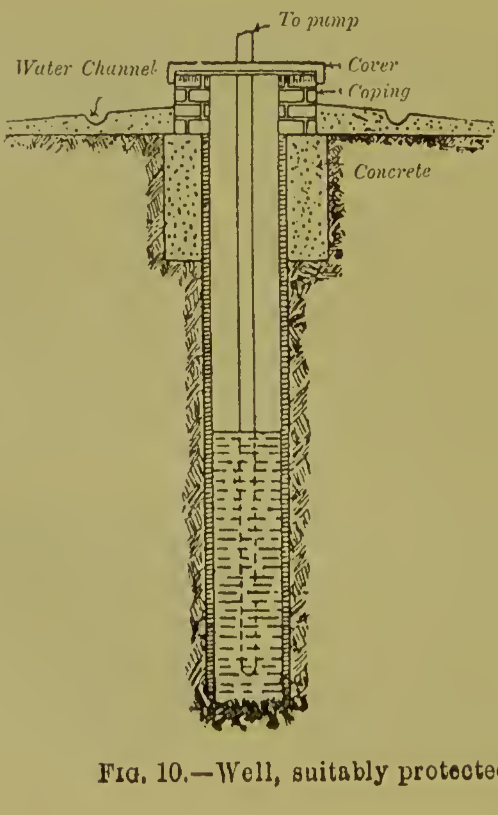

FIG. 10.—Well, suitably protected.

of other wells or sources nearer at hand; they should be remote from latrines. In cantonments shallow private wells if not thoroughly well constructed and their method of use constantly supervised are usually contaminated; and if not properly steined and protected they should be condemned, disused, and filled up or permanently covered up with slabs of reinforced concrete, stone or other locally available material.

As far as practicable the water of all wells should be drawn by *pumps.* The mouth of the well should be covered to prevent dust and light reaching the water, also to prevent bird droppings, leaves and insects of all kinds, especially mosquitoes, gaining access. Whenever possible, the suction pipe of the pump should be at one side of, and not immediately over, the well, the pipe attached to the pump being arranged so as to admit of this. The employment of pumps would remove the difficulties of drawing water in the way it is usually done in this country from wells. "The lift and force pump is in most general use in the service. It is worked by two men. It can lift water from 20 to 28 feet, and force the water to a height of 60 feet from its former level, delivering 12 gallons per minute." The provision of pumps would prevent the introduction of private utensils, which are often unclean, and sometimes infected.

In the absence of a proper complete cover and pump, such as that shown in the illustration (Fig. 10), a wooden cover might be provided having a door which should only be opened when water is being drawn. This would lessen the chances of pollution of the water by the inhabitants. Another improvement would be to have the mouth of the well as small as compatible with convenience. When unprovided with a pump a stone or brick parapet wall should be constructed around the mouth of the well to a height of two feet at least. This prevents surface water flowing into the well. The ground around the base of the parapet wall of the well should also be provided with a sloping pavement (preferably one of concrete) of at least 10 feet in width, the outer edge ending in a circular channel or drain (also *pukka*) to convey all refuse waste water from the well to a drain running at right angles and ending in the public surface drain, or in a cistern (from which the water should be periodically removed), or running to some waste land or *nullah.* If this precaution is not adopted, during the dry weather fissures occurring in the surface soil around the mouth of the well, allow of water falling on the surface to drain directly into the well. This pavement and drainage around the well is necessary amongst other things to prevent the formation of pools.

Where pumps do not exist and cannot be provided, and buckets must be used, those of iron or galvanised zinc, attached to iron chains, are preferable. Dirty utensils should not be used to draw water from wells—people should be prohibited from using *lotahs,* leather buckets, and other utensils attached to dirty ropes, as such articles often

contain disease germs. The metal bucket and iron chain should be kept constantly at the well. The difficulty in connection with caste prejudice may be overcome by having separate marked buckets for different castes.

No trees should overhang wells as their leaves fall into the water and decay, while their roots grow into the well breaking the lining in doing so.

If cattle are used for drawing water, they should be made to pull on the level, and not into sloping excavated runs as is usually done. These latter during the rains fill with water, and form breeding places for mosquitoes.

In officers' bungalows where wells are the source of drinking water a pump should also be provided, and when this is not possible the well should be converted into a house well, with a door provided with a lock and key to prevent all unauthorised persons gaining access to it.

Wherever well-water is used for troops, the well should be adequately covered, steined, all pollution from the surface guarded against, and a pump provided. In the case of deep wells a force pump is required with connecting rods to the piston, and there should always be means of repairing these should they get out of order.

All cantonment well-water is polluted; from both superficial and deep wells the *bacillus coli communis*, a normal inhabitant of the bowel, may be cultivated.

Yield of a well.—In measuring the supply of a well, we note its shape, calculate the area of its horizontal section, take its depth, mark the line to which the water reaches, pump it dry, and ascertain the time it takes to fill to the water mark from the time of stopping the pumping. Wells are as a rule rectangular or circular. In a rectangular well the area is, of course, the length multiplied by the breadth; in a circular well it is the square of the diameter multiplied by 0·7854. In a circular well 3 feet in diameter and 12 feet deep, if the time it takes to fill is 5 hours, then 3×3 (square of diameter) $\times 0{\cdot}7854 = 7{\cdot}07$, the area of the cross-section of the well in square feet; this multiplied by $12 = 85$ cubic feet nearly, the contents of the well. As 1 cubic foot $= 6{\cdot}24$ gallons, the contents of the well are 530 gallons, which quantity is yielded in 5 hours. Therefore the yield in 24 hours is $5 : 24 : 530 : x = 2{,}544$ gallons. The yield of a well differs at different seasons and in different years.

Tank water.—In exceptional instances it may be necessary to use tank water (that is, water from small or large artificial ponds) on field service. A large proportion of the people of India depend entirely on tank water for drinking and other purposes. When these tanks were originally constructed, the water was probably more or less wholesome;

but the inhabitants in process of time have by their habits rendered it of doubtful quality. The causes of pollution of tank water are many, and to a large extent similar to those in operation in rivers. The effluent of house or village drains is frequently permitted to enter tanks.

It should be remembered that tank water deteriorates during the hot weather as a result of putrefaction and fermentation of animal and vegetable matter, but during the rains, its quality is improved as its impurities become less concentrated. It is always charged with animal and vegetable matter, and swarms with living organisms, especially during the dry weather. It is during this part of the year that the public health suffers so much from its consumption. The water of rapidly drying up tanks is usually very impure. Water of average temperature containing much organic matter will always be a potential breeding place for disease germs. The water in tanks in the dry weather is a constantly decreasing quantity, whilst its impurities are becoming progressively greater. The surface drainage of the ground around the tank should be prevented from flowing into it, unless such drainage is the absolute means of feeding the tank. The effluent from irrigated land should be prevented from entering tanks. This may be done by raising the banks above the level of the surrounding ground.

The many sources of contamination to which tanks in the vicinity of towns and villages are subjected, render the water always dangerous, without previous sterilisation by boiling and filtration. The larger tanks, however, may contain purer water than ordinary rivers. We should remember that a well or tank water that has been infected to only a very slight extent, if the source of infection be not removed, may acquire dangerous qualities with a little greater infection, or under more favourable circumstances. Such a water is a perpetual menace to the health of the consumers.

No trees should be allowed to grow near tanks, for the falling leaves are blown into, and decay in, the tank water. All decayed and decaying plants should be removed from tanks. Certain plants and almost all fish are useful in purifying tank water when they are not in excess. Such plants act chemically on the water by giving out oxygen, and fish feed on the smaller animals contained in the water—crustaceans, insects, and on organic matter. Whenever running water is not available, and often even when it is, the water for animals should be drawn and run into drinking troughs of canvas or wood.

Irrigation effluent.—The effluent from irrigated land, particularly that from rice-fields, is exceedingly impure and dangerous to use for drinking purposes. In some agricultural districts in India, such water forms a principal source of supply. The fields are regularly manured and contain decaying vegetable and animal matter. The combination of putrefying animal and vegetable organic matter in such water is most pernicious to the well-being of those who drink it.

Jheels and marshes.—The water of *jheels* and *marshes* is one of the most unwholesome that can be used. It is decidedly impure, containing an abundance of decaying vegetable matter (from 10 to 40 grains per gallon), although it sometimes has the appearance of being pure. Such water should never be drunk without boiling and filtration.

Ditches, pools, ponds.—The water of ditches, pools, and ponds, is likewise excessively impure, especially if they are close to human habitations It is usually stagnant, foul, and full of organic matter, including living organisms, animal and

vegetable Its consumption is always associated with great danger to health, and if its use is unavoidable, it should be boiled and filtered before being issued for drinking purposes. Ponds and pools containing stagnant water are liable to be polluted in the same ways as mentioned regarding tanks, including contamination from the large number of animals using them. Naturally, the smaller volume of the water, with daily evaporation from them, leads to progressively increasing pollution.

We should therefore for drinking purposes avoid all surface water, very shallow wells, unprotected tank, *nullah* and pond water, and whenever compelled to drink such water it should first be boiled and filtered.

Conveyance of water to troops.—The method of transporting water to troops is an important matter. In the case of supply from wells, tanks, streams and rivers, the usual method is to carry the water in metal vessels. Another method of distribution is by means of *masakhs* and leather *pakhals* (bullock skins usually carried in pairs slung across the back of a bullock, mule or pony). A *masakh* is the skin of a goat sewn up, the neck forming the part that is used to fill and empty the *masakh*. When containing water the neck is encircled with a leather thong or piece of string. *Masakhs* are often lined with a layer of slimy material laden with the germs of disease, the common colon bacillus being seldom absent. *Masakhs* are never cleaned, and are kept in use until they fall to pieces by wear, tear, and rottenness. If the water contains dysentery, cholera, or typhoid germs, these rapidly multiply in the *masakhs*. Disease germs purposely sown on the outer surface of *masakhs* have been found to grow into it through the skin, the gelatine of the skin affording a good medium for their multiplication. This method of specific contamination of water is constantly occurring through the habit of *bhistis* throwing the empty or full *masakhs* on the ground. *Masakhs* should be condemned and looked upon as abominations of the past. The same remarks apply to leather *pakhals*. One would here condemn their use throughout this country. They are not used in the Army now, metal *pakhals* have taken their place with great advantage to the health of the troops. Metal vessels should be used for the service of water when possible. The brass vessels used by all classes of natives, especially Hindus, probably help to purify the water by acting on disease micro-organisms, and bright copper utensils are more useful in this respect. Experiments have shown that iron and copper prevent to some extent the growth of germs in water. The ordinary kerosine oil tin, kept clean and bright, is a useful and cheap utensil in which to convey water for house consumption. These remarks hold good regarding the carrying of water for use from wells, tanks, and other sources.

B.—Public Water-works for Cantonments.

It ought to be a recognised principle of Indian military sanitation, that wherever a permanent supply of good water is available, it should be provided for cantonments. No reasonable labour or expense should be spared to get water from a pure source. It is only by so doing that

we can reduce the many possible channels of water-borne infective disease reaching our troops. Locked up in water pipes it cannot be got at. We must remember that a deficiency of pure water in a community brings about accumulation of filth in all its forms, with all its evils.

The source of supply for public water-works may be from rivers, streams, deep wells, artificial or natural lakes, artificial adits, and from gathering grounds. In the last named case all fouling of the catchment area is to be prevented.

Public water-supply from rivers.—When a river is selected as a public water-supply source, the water should be taken from the main stream, and not from any back current, stagnant or shallow part of the river near the bank. For permanent supplies on a large scale, the inlet water pipe should go well into the water at a distance from the bank. It is generally in connection with a pump which raises the water into a tank or settling reservoir. The banks of the river for some miles above the intake should be protected on both sides for a distance of 100 yards by means of wire fences to prevent access to the water of animals and men. The whole of this area should be periodically inspected to see that there is no source of pollution in either the main stream, or its tributaries (if any). No villages should exist on the banks of the river for some distance above the intake. When the river is used for watering animals, washing clothes, and supplying drinking water, the latter should be from above the other two, and the washing carried out lowest down.

Rivers in India are usually large in volume, the actual sewage of towns does not reach them except in flood times, and there are few manufactories on the banks to pollute the water. In some towns, however, the surface drains are constructed to carry the sullage water (which frequently contains part of the sewage) direct to rivers, without any attempt at previous purification. On the whole, however, public water-supplies from large and medium-sized rivers in India have been proved to be satisfactory. On the other hand supplies from small and shallow rivers are always dangerous, especially in thickly populated districts.

Excellent water-supplies are often yielded by the creation of artificial lakes by erecting dams across the most suitable streams available, which streams come from some upland area. These are known as *impounded reservoirs*, which act as settling reservoirs. Means are provided for diverting the tributary streams, if such exist, along a *by-wash*, when they become foul in flood time.

The impounded reservoir is also provided with an *overflow weir*, and can be emptied for cleansing purposes by means of a pipe, controlled by a sluice, leading from its lowest points. The water is usually taken from the impounded reservoir by an iron outlet pipe which is bent upwards at first so as to take up only the clearest water from the reservoir to the filter beds. The pipe, which should be lined with pitch or some other anti-corrosive, is buried along its course in the ground for a few feet. It is rendered accessible at short intervals for cleaning. Sluices are provided at the lowest points when the pipes are laid in undulating ground, and air-vents are provided at the summits. Open aqueducts of stone or brick are most undesirable as they are exposed to contamination in various ways. When such open conduits are unavoidable, direct access to the water must be prevented throughout their course by barbed wire fencing or by other means.

Artificial reservoirs for public water-supplies.—*Reservoir Sites.*—In choosing the site of a reservoir for a public water-supply the engineer has three main points to consider—the elevation of the site, the configuration of the surrounding country, and the materials for the work, especially those materials which will form the foundations of the embankment or embankments by which the water is to be retained.

The elevation of the site must at once be so high that from the lowest water-level there shall be sufficient fall for the pipes, conduits, or other channels by which the water is to be discharged, and at the same time so low that there shall be a sufficient gathering ground above the highest water-level. Storage reservoirs are usually made by impounding the water from the gathering grounds in such a position that water is supplied by gravitation.

In sinking a new reservoir excavation, the whole area should be cleaned, cleared of trees, bushes, scrub, stumps of trees, all filth, loam, and organic matter generally, and finally a foot of soil dug up. The excavation should be carried down to a depth of 12 to 15 feet. It is preferable that the inner surface of the bank should not slope, but the perpendicular. This prevents the growth and decay of aquatic plants, and is unfavourable to the development of anopheline larvæ.

The appendages of the store reservoirs are the same as those of impounded reservoirs across valleys previously mentioned.

Water sluices may be opened to assist the waste weir in discharging an excessive supply of water. They may either be under the control of a man in charge of the reservoir, or they may be self-acting.

The *available capacity*, or storage room of a reservoir, is the volume contained between the lowest working water-levels, and is less than the *total capacity* by the volume of the space below the lowest working water-level, which space is left as a place for the collection of sediment, and is either kept always full, or only empty when it is absolutely necessary to do so for cleansing or repair. It is impossible to lay down a fixed rule as to how much the space so left, or "bottom" as it is called, should be, but in some good examples of artificial reservoirs, it occupies about one-sixth of the greatest depth of the water at the deepest part of the reservoir.

The absolute storage room required in a reservoir is regulated by two circumstances—the demand for water, and the extent to which the supply fluctuates.

The best rule for estimating the *available* capacity required in a store reservoir would probably be one founded on taking into account the supply as well as the demand. Large volumes of standing water in India, such as those of tanks, and open reservoirs, lose about 5 feet of water per annum by evaporation and absorption.

Where there is any liability to intermission from the source of supply, reservoirs of large capacity are indispensable.

The reservoir should be fenced in. It should be away from villages and habitations. No building should be allowed near it. Access to the water should be rendered impossible. The surroundings of the reservoir lake should be free from all possible sources of contamination. The conduits leading to the tank require periodical inspection.

The reservoir is to be regularly inspected by the cantonment sanitary officer and engineer (when there are these officials) to see that it is kept free from all forms of contamination (the water being analysed and examined bacteriologically) and that it is in complete working order.

Aquatic vegetation in reservoirs.—Some plants help to purify water, and of those met with in Indian waters the best are:—*Nymphea rubra* (species of water-lily), which has long india-rubber like stems and deep-red or blood-coloured ferners; and *Vallisneria octandra*, the water plant used by sugar refiners in some factories in India to cleanse their raw sugars.

In addition to the higher order of plants, there are a large number of cryptogams or non-flowering plants, such as *algæ*, duckweeds, etc., which flourish in water, and generally in tanks or ponds, where they float about in masses, sometimes covering the whole surface with a green scum. The decay of such vegetable matter is injurious to the quality of the water. They afford cover and food for larvæ of mosquitoes When clearing tanks or reservoirs of weeds, plants, etc., the vegetation should be entirely removed from the vicinity of the tank and not allowed to decay on the banks.

The growth of algæ and cryptogams generally in reservoirs, lakes, and tanks, often gives an objectionable smell, taste, and appearance, to water. These may be prevented to some extent by having the tank from 12 to 15 feet deep (in which depth of water algæ and aquatic vegetation generally do not thrive), the banks perpendicular and not sloping, and the occasional use of sulphate of copper in the water. This latter may, in large collections, be used by hanging the sulphate of copper in bags over the side of a boat and rowing round the lake or tank occasionally. Sulphate of copper is also used in some water-supplies to prevent the growth of typhoid and other bacteria. Old reservoirs or lakes cannot, of course, be deepened, but the other means suggested as well as periodical dredging of water plants can be carried out.

Fish in reservoirs.—As a rule fish are instrumental in purifying water, and for this purpose their presence is often very necessary. Fish prevent the overgrowth of vegetable matter, and feed upon the insects and crustaceans and the dead organic matter present in the water. The destruction of fish contained in large volumes of water has led to increase in the number of small crustaceans on which the fish had lived, rendering the water impure and nauseous. In such cases the remedy is to re-stock the tank or reservoir with fish. Of fish, the best suited for stocking tanks are the *katla, ruho* or *rooi, mirgal, kalla, kalaboas,* all of the carp family (*Cyprinidæ*), are the most desirable. The *chilwa* is also useful in this respect.

Filter beds.—The water from the settling, storage, or impounded reservoir is conveyed to the filter beds, usually in jointed cast-iron pipes.

The filter beds of public water-supplies are usually large rectangular, covered, cemented, brick, or masonry chambers, in the floors of which are drains or channels for gathering the filtered water. The chambers are usually about 10 feet deep. The actual filter beds are from 5 to 6 feet deep and made up from the bottom of broken stones or pebbles, covered with coarse gravel, on which is placed a layer of coarse sand, and finally a layer of fine sand. The sand should form 70 to 80 per cent. of the filtering media. The water resting on

the sand is 4 or 5 feet deep, and should not pass through the filter at a higher rate than 4 inches an hour.

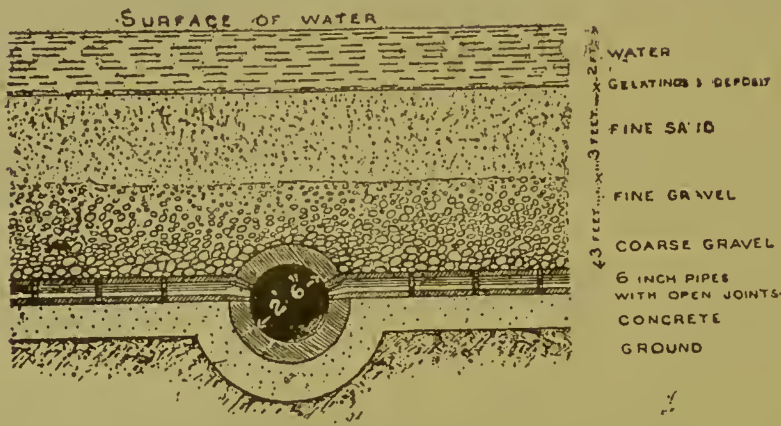

FIG. 11.—Section of Sand Filter Bed.

This filtration process abstracts suspended matter, and practically all the bacilli of the water. The purifying effect as regards bacteria depends on a layer of micro-organisms which rest on or near the surface of the filter. "On this surface there is a slimy layer, composed of finely divided clay and a gelatinous mass of intercepted bacilli, streptococci, micrococci, algæ and other bodies, and immediately below this film is a layer of nitrifying organisms. It is this slimy layer in the sand which is the most important factor in removing micro-organisms and the organic matter from the water. There are more filtered micro-organisms in the deeper than in the superficial part of the slimy layer. By the film pathogenic micro-organisms are intercepted and destroyed, the organic matter is broken up into carbonic acid and ammonia, while by the nitrifying micro-organisms, the ammonia is changed into nitrous and nitric acids. The filters when acting effectually remove from 98 to 99 per cent. of the bacteria."

There should then in all these filters be a fine layer of slime; this should not be disturbed, but when the slime becomes too thick for the water to pass through, it should be removed by scraping the surface. In removing the film only half an inch of sand should be scraped off after which the superficial part of the rest should be raked up so as to expose it to the air and then smoothed over. When the sand is reduced to a foot thick, the whole filter is cleansed.

Vents are constructed in some filters; they are carried from the deeper layers to above the surface of the water to permit of the escape of the air displaced by the water when it first passes into the sand.

The degree of efficiency with which a filter bed is acting can only be ascertained by systematic and routine chemical and bacteriological examination of the filtered water, and the bacteriological examination should invariably include an estimation of the number of bacteria contained in a cubic centimetre of the water.

The filter beds are periodically allowed to run dry for the purpose of aeration. The sediment from the surface layer is occasionally scraped off. When there is any risk of the fine surface sand being insufficient to carry out its essential office, more is added.

From the filter beds, the filtered water flows to the *service reservoirs*, which are covered chambers to protect the water from sun and contamination, whence it is distributed either by gravitation or by pumping, to the different parts of the town, municipality, or cantonment. In most stations in India a pumping station is required to cause the water to reach the height necessary.

Service reservoirs are covered and ventilated. They should be deep rather than of large surface area, as this tends to keep them cool and prevents evaporation. They should only be filled with safe and purified water. This is specially necessary when the source is from a surface water. Service reservoirs filled from deep wells seldom need filtration. It is necessary to prevent the growth of algæ, fungi and other organisms in the water; this is effected by the exclusion of light. All reservoirs require to be cleaned out periodically. Impounded or storage and service reservoirs are when practicable located on as high ground as possible so as to secure a sufficient head of pressure to supply all parts of the town, municipality or cantonment, with water by gravitation. From the service reservoirs the water is distributed in cast-iron pipes.

Water-pipes.—Water is conveyed to the barracks in pipes. The larger ones are of cast-iron, the smaller galvanised iron, lead, tin, or vitreous glazed iron pipes. Iron is best. Lead is not used when the water is soft. Distribution by hand or carts should be avoided if possible, for this usually means a scanty supply, and the possibilities of contamination *en route* to the consumers are many. Deposits may take place in water-pipes and water channels. Deposits in iron pipes are from the iron itself, and may be prevented by coating the interior of the pipe with some bituminous material. Other deposits occur in any kind of pipe or water channel, consisting of a slimy material containing different kinds of germs. These may be prevented in one of many ways, especially by Clarke's softening process which consists in adding a small quantity of lime to the water.

In large stations and towns *supplementary service reservoirs* are sometimes constructed in the higher parts, for convenience of distribution to particular areas, partly to supplement the supply from the main reservoir during the hours of the largest call on the water-supply. If this is not done it is necessary to have the mains capable of yielding a full supply at the hours of maximum consumption, which is over twice that of the average consumption per hour.

The distributing mains are similar in construction to the main aqueducts, and have scouring valves at all dead ends in order to wash out sediment There is danger of insuction if any perforation or leaking joint occurs in a descending pipe, and this may occur when the pipe is running quite full.

Along the streets of towns, and in barracks in cantonments, *stand-pipes* with taps or stop cocks are connected with the water-pipes. Hydrants are also provided at intervals for use in case of fire and for watering streets.

Service pipes carry water to the barracks; they are usually controlled by stop-cocks.

One of the greatest advantages of public water-works is the doing away with the manual labour in connection with the drawing of water from wells and tanks. They reduce this labour practically to *nil.* Carried out in their perfected methods, they give a constant supply of water to every barrack and house at any time without any expenditure of energy on the part of the consumer, and do away with the risks associated with house and barrack storage of water.

Constant and intermittent supply.—In the *constant* system the mains and service pipes are kept constantly filled under pressure sufficient to raise the water to the highest stories of houses and barracks, and there is no actual restriction as to the amount of water that each person may draw.

In the intermittent system the water is cut off from the smaller mains, except for 20 minutes or half an hour, once or twice a day. It is a common error to suppose that the constant service means an unlimited supply, and the intermittent a very much restricted one.

Constant supply.—All drinking water ought to be drawn direct from the mains, under proper supervision; the waste of water is less in the constant than it is in the intermittent system of supply. These and other advantages have led to the adoption of the constant system in the great majority of British towns. The constant is immeasurably superior to the intermittent, so that unless its inapplicability in any particular case should be decided by competent engineering authorities, it should be adopted as the only method by which the growing necessities of the people can be fully and effectively satisfied. The disadvantages of the constant system are said to be that great waste and extravagance of water is encouraged; but with proper fitting taps, waste water preventers, and waste meters, these could be avoided. The great advantages of a constant system of water-supply, and the practicability of its adoption, have been abundantly demonstrated in various towns in India, and these examples are not unworthy of universal imitation.

In the intermittent supply the contact of the pipes with air and water alternately tends to rust them. A house or part of a town supplied on the intermittent system is at a great disadvantage in case of a fire breaking out. In the intermittent supply it is necessary for each house to store enough water for 24 hours in cisterns or other utensils. Water stored in barrack cisterns and water containers always means the risk of contamination. Where cisterns exist in barracks they should be covered, protected from both heat and light, and thoroughly ventilated.

Where barrack cisterns are indispensable, they are best constructed of well jointed brick or stone slabs, which should be thoroughly

cemented inside. A wrought-iron cistern coated with some bituminous compound is also largely used. The ordinary iron tank reservoir similarly coated is very useful, although from the absence of fresh air, if it is not thoroughly looked after, the water in it rapidly deteriorates. One has repeatedly found the larvæ of mosquitoes in the iron tanks providing troops with water in standing camps during manœuvres Lead cisterns should never be used in a barrack. Galvanised iron is objectionable. *Wooden* cisterns should be avoided, as the wood is apt to decay, to favour the putrefaction of, and impart organic impurity to, the water. Another important point is that the service pipes which convey the water from the mains and sub-mains to the house-tops or cisterns should never be composed of lead or galvanised iron. A safe pipe is a leaden one lined with block tin.

Any water collected in the barrack for intermittent use during the day should be carefully protected from all possible sources of pollutiou and the receptacle for the water should be periodically cleaned.

In some cases cisterns are a necessary evil, but knowing the dangers associated with such storage, precautious in proportion should be taken to preserve the purity of the water. Storage on a large or small scale undoubtedly accelerates the deterioration of water; particularly is this so in covered reservoirs, where from stagnation, warmth and limited supply of oxygen, micro-organisms in the water multiply rapidly. Both putrefactive and pathogenic germs rapidly multiply in water under favourable circumstances. In a stagnant water it does not signify how many micro-organisms are present to begin with, for in a short time it teems with them.

The impurities of house stored water may be lessened considerably by fitting on to the cistern either a Berkefeld or a Pasteur-Chamberland filter, the number of caudles to be used depending on the quantity of filtered water required.

The intermittent supply is very unpopular and is now seldom adopted in new water-works. The risks of stored water in India are so great and the disadvautages of this system so numerous, that one has no hesitation in stating that wherever possible the constaut system should be adopted

It is very rare for the water from the filter beds of cantonmeut supplies to be found to contain the specific germs of water-borne diseases; one personally kuows of no instance in which such contamination has been proved in this couutry. These supplies are rigidly watched and regularly subjected to bacteriological examinations; so that, provided every possible precaution is taken against contamination between the filter beds and actual consumption by the meu in the barrack-rooms, there should be no risk. It is the probability of such contamination in its distribution that necessitates our recommending that all water for the men should be boiled. The possible sources of such pollution in and around the barracks are so numerous that it is necessary to safeguard our men from all risks by boiling the

water. In cold weather all water in barracks should be from the taps direct—storage is unnecessary. In the hot weather it is necessary to cool the water. This is done in some regiments by the use of thick canvas bags with locked covers above and a tap or taps below. *Soorahies* are largely used as they naturally keep the water cool by evaporation from the surface. Their great disadvantage is that they are drunk out of directly, and the mouth of the *soorahie* is often not covered. This could be readily remedied by having a clean muslin cover tied on, or a tin cover fixed on, and having an enamelled mug attached. The ultimate distribution of water to the soldier in the hot weather requires the closest attention of the officer commanding the company and of the section commanders.

The water of public water-works may be polluted at its source, in the conduits, in reservoirs, during distribution, or in the barrack-room cisterns or water containers of all kinds. Pollution during distribution is very common in many obvious ways. Water during storage may be subjected to contamination in various ways, especially when the containers are directly accessible and not covered. This latter allows of dust, insects and the men themselves getting at the water.

Under all circumstances waste of water, even when it is abundant, should be strictly forbidden. Such prodigality may in some situations be very disastrous.

C.—Diseases caused by impure water.

As far as the soldier in India is concerned, polluted water may give rise to the following diseases :—Typhoid fever, dysentery (both bacillary and amœbic), infective diarrhœa, simple diarrhœa, cholera, various kinds of worms, including guinea-worm, round worms and hook-worm disease and indigestion.

Simple diarrhœa.—Impure water plays an important part in producing ordinary simple diarrhœa. This is especially the case if the impurity arises from decomposing animal and vegetable matter. Such decaying animal matter is most frequently derived from human ordure, which in some way or other gains access to and mixes with drinking-water. Sometimes, however, dissolved and undissolved mineral matters contained in water create relaxation of the bowels. The diarrhœa so prevalent in the Himalayas is often due to the suspended mica scales, or finely divided particles of silica contained in the water.

Epidemic or infective diarrhœa.—Impure water plays an important part also in producing epidemic diarrhœa which arises from infection of the water by a bacillus which is very like that of epidemic or bacillary dysentery.

Dysentery.—Dysentery may also be caused by impure water when the impurity consists of one or other of the specific bacteria of dysentery (*Bacillus dysenteriæ*).* It is probable that a second form of dysentery

* What is known as the *bacillus of dysentery* is not a single species, but a group of closely related bacilli, of which three distinct and several closely allied species are recognised.

arises from the use of water to which another organism gains access. This is known as *amœbic dysentery* and is due to a small animal organism. It is a sound rule to assume that any epidemic outbreak of bowel complaints in cantonments or on field service, manœuvres, etc., may be due to infection of the general water-supply, to which the attention of the sanitary and regimental medical officers should be directed.

Typhoid fever.—This disease arises chiefly from water fouled by the stools or urine of patients suffering from it or who have recently recovered from it. It does not often affect the people of India, but is very fatal to young Europeans coming to the country. It occasionally arises from the use of specifically contaminated water used by *gowallahs* to adulterate milk or to wash milk containers.

Cholera—its relation to water.—Cholera is endemic—that is, it is always present to a greater or less extent—in Lower Bengal and certain other parts of India. It has in these places occasional epidemic outbreaks; but an entire cessation of the disease occurs only for a few months of the year. When the conditions favourable to the propagation of this disease are present, and it has once made its appearance, it is liable to disseminate to other parts of India epidemically. Water is one of the chief means by which the disease is spread. There are doubtless other agencies by which it is diffused, such as through specifically contaminated air, clothes, food, flies, etc., yet water in most outbreaks plays an important part in this respect. One thing is certain—wherever in its endemic centres the use of unwholesome water has been supplanted by a purer supply, there cholera has considerably decreased.

A direct proof of the contagiousness of the excreta of cholera patients is given in the following case. A part of the evacuation of a cholera patient was mixed, by accident or otherwise, in the water contained in a *ghurrah* or earthenware chatty. The *ghurrah* was exposed to the sun for many hours. Next morning each of 19 persons swallowed a small quantity of this water. Within 36 hours five of them were seized with cholera. Another recorded instance is given, where the supposed germ of cholera was found in the water of a tank in Calcutta. A woman who drank of this water was attacked with the disease. Cholera bacilli have now been frequently found in water-supplies from wells and tanks in this country. Cholera sometimes attacks large numbers of people at one time, and spreads rapidly over the country. Its spread is nearly always along the line of railway, or along roads travelled by human beings. Epidemics of cholera never travel faster than human beings can. We can explain how this spreading occurs. Say a wayfarer imbibes the poison of the disease in Calcutta, but does not show signs of it till he has entered the train. His discharges are deposited within the compartment he occupies. It soon dries up into a fine powder and contaminates the air. This air is breathed by other passengers, or the dried up particles get to the back of the throat and are eventually swallowed. Or, he visits the latrines at the railway stations during his journey. The excreta from these may start the disease in he stations. Further, suppose the man recovers. He takes his soiled clothes to some well and washes them at its margin; some of the slops find their way into the well, and render all those who use the water liable to cholera. He likewise carries out his personal ablutions at this well. This may appear to be a far-fetched explanation, but we can vouch for its reality.

When Health Officer of a large municipality, and whilst on one occasion seeking the cause of an outbreak of cholera, one entered several huts where patients were suffering from the disease. In one hut lay a helpless man in a low state

from cholera. He had passed his stools over the ground, and had vomited in several places, soiling the cooking utensils and his *lotah*.* On making inquiries it was ascertained that his wife had just drunk water out of the *lotah* so soiled. The man recovered, but the unfortunate woman died of cholera. On another occasion, a woman drawing water while in the stage of premonitory diarrhœa from cholera, vomited and purged into the well. In two days 37 people of the village using the water of this well were attacked with cholera. On one occasion while investigating a localised outbreak of cholera in company with a newly-employed sanitary inspector, and when demonstrating to him that the rice-watery evacuation from one of the cases was characteristic of cholera, he remarked that he had been passing that kind of excreta for five days. He died from cholera 36 hours later. In the same way many mild cases of diarrhœa occurring during cholera epidemics are really cholera; these are amongst the most dangerous to communities, because no precautions against the spread of the disease are taken. There are, unfortunately, other persons during cholera periods who are perfectly well and yet act as carriers of the disease through their excreta, which are normal in appearance, containing cholera bacilli.† We have seen how all wells, tanks, and water-courses are being constantly polluted, and how easy it is for the cholera poison to reach us; all this might be avoided by the exercise of a little care regarding the water we drink.

In the year 1879 over five millions of people died in India, 265,000 of these from cholera. During cholera outbreaks the one cardinal rule to adopt is to boil all water that is drunk and see that it is boiled; this rule includes also all milk used when it is from any source outside one's own premises.

Worms.—The human being is liable to suffer from several kinds of "worms." The eggs, and embryoes or immature forms of these parasites, may gain entrance to the bowels through drinking-water. Amongst these are round worm, thread worm and guinea-worm; others, as the ankylostomes or hook-worms, are taken into the body with drinking water and also reach the bowel by attacking the skin. Many vegetable parasites are said to come from bathing in impure water, such as ring-worm.

Intimate relation between water and disease.—All evidence shows the intimate relation between impure water and disease. The rapid strides made in the investigation of disease-causes place us in a position to state that the nature and quality of the water used by a force on field service and in cantonments is a matter of vital significance.

We can never ignore the fact that the most prevalent and deadly diseases of India (except plague, small-pox, tuberculosis and malaria) may be water-borne, and that practically all extensive epidemics of these diseases arise either directly or indirectly from specifically polluted water. If we neglected our water-supply or depended on the methods of supply we adopted say 25 years ago, we would once more get the appalling epidemics of water-borne disease that used to occur at that period. When the supply is not absolutely reliable it is necessary to recognise that contamination may occur in any stage up to reaching the consumer.

* The brass utensil used for drinking out of.
† See article *Cholera*, PART IV.

D.—Examination of Water.

Collection of samples of water.—It is often necessary to *collect samples of water for analytical and bacteriological examination*, and in doing this much care is necessary. In taking a sample for this purpose in India we usually fill with the water a scrupulously clean "Winchester quart bottle" (which contains half a gallon) having a rubber stopper. This bottle is placed in a specially made wooden box containing a perforated piece of wood to receive the neck, and clamped with nuts to keep the bottle steady. The bottle is surrounded with broken ice and despatched to the analyser as soon as possible; this precaution is specially necessary when the water has to be sent to another station. If not packed in ice, the germs, which are contained in all natural waters, multiply with enormous rapidity, so that in 24 hours or so, the sample does not represent the state of the water being used. So much so is this the case that as far as a bacteriological examination is concerned, if the water does not reach the examiner within 24 hours in the hot weather, and 48 hours in the cold weather, it is useless to send it.* The chemical constitution of the water remains unaltered. All thoroughly clean glass stoppered bottles may be made to answer the purpose of the one described above.

In collecting water from a tank or well, the surface impurities, scum, and debris should be avoided by immersing the bottle and removing the stopper under water; care should also be taken not to stir up any sediment or dirt from the bottom. The middle of a stream, river or tank should be chosen, avoiding the intake of feeding channels, unless it is essential to test the water from a particular spot. If from a public water-works tap or stand-pipe, the tap should be opened for a few seconds before filling the bottle. The bottle should be washed out three or four times with some of the water to be examined before taking the sample. The bottle should be completely filled. The stopper of the bottle should be tied in. A note should be made of the source of the water and of the date and time of taking the sample.

Trained sanitary officers exercise the utmost caution in expressing their opinions as to the quality of waters analysed by them, for they are conscious of the importance of their decision. It is but fair, then, that in sending samples for analysis, such samples should be accompanied by as much information about the water as it is in our power to give. It is often a waste of time and labour to send six or eight bottles of water marked A, B, C, etc., without any further reference to the water sent. He should also be made acquainted with any special reason there may be for making an analysis.

Methods of examination adopted.—An accurate opinion as to the wholesomeness or otherwise of a drinking water can only be arrived at after subjecting a sample of it to a complete examination. This consists in an investigation into the *physical characters of the water*, a *chemical analysis* (both qualitative and quantitative) and a *microscopical examination*. Yet after all these processes have been carried out, there is a further requirement—that of an endeavour to cultivate any microscopical vegetable germs that may be present in suitable nutrient media, and ascertain their nature. This is termed the *bacteriological* or *biological examination* of water. When this also has been accomplished, we are placed in a position to give the most reliable and trustworthy opinion as to the quality of a given sample of water. To carry out these processes with accuracy demands that the analyst shall have had a sound chemical training, and that he be familiar with bacteriological methods.

* The bacteria in a sample of water multiply with enormous rapidity for 24 hours, and continue to do so for three or four days, then they undergo gradual reduction, and in a few months there are practically none remaining. The bacteria of water are mainly affected by the temperature of the water, length of time it has stood, and the nature of the organic food in the water.

Hence the uselessness of lay persons undertaking anything but a physical and simple chemical examination of water. On the other hand, in the majority of cases, a sufficiently trustworthy opinion can be formed as to the quality of a water after a physical and chemical examination of it has been made by a sanitary expert.

Physical examination of water.—Much may be learnt from a simple physical examination. From it we ascertain the *colour*, *clearness*, *taste* and *smell* (if any), and the existence or not of any visible *suspended matter* or *sediment*.

Colour.—For this we use narrow cylindrical, clear glass vessels, about 18 inches in height. We fill one with the water under examination, and the other with distilled water for comparison. We place these in a good light, on a white slab or on some printed paper, and see if we can read the print below. The best and purest waters have no colour when seen through this depth, or only a faint bluish tinge. In practice we would probably fill some vessel like a soda-water tumbler and judge how far it responded to this test without any distilled water for comparison to guide us.

Waters are often slightly *greenish*, due to cellular *algæ*, and such waters are not considered impure on this account. Waters of a *yellowish*, or a *brownish* colour, are to be looked upon with suspicion. Such a colour may be due to sewage contamination.

Clearness.—Any water that is not clear and transparent cannot be reckoned as one of the first order. Dissolved or finely suspended particles of colouring matters will reduce the natural clearness of pure water, as will also finely divided and suspended mineral matters. Most of such suspended matters subside on allowing the water to stand, but fine particles of calcareous salts. and of mica, etc., may not subside.

Sediment.—To find out the amount and nature of the sediment the water is to be allowed to stand some time. The general characters of the sediment may now be investigated. It may be examined microscopically and biologically, and in this way its exact nature be discovered.

Taste.—The taste of a drinking water depends, as a rule, on the gases dissolved in it, and not on the mineral salts it contains. It may be said that any water in which the mineral matters in solution are recognised by the palate is unfit to drink. An ordinary drinking water contains from 1·5 to 2·5 grains of common salt to the gallon. It requires about three times this quantity to be readily recognisable by the sense of taste.

Smell.—Any perceptible smell in water should cause us to regard it with suspicion. A smell is usually due to putrefaction in which the evolution of sulphuretted hydrogen and ammonia compounds is taking place. Any smell in water is best brought out by heating it to about 100° Fahr., and adding a little caustic soda to the water.

The sense of touch requires considerable practice before it can be of use in the physical examination of water. It is chiefly employed in detecting hardness in water, hard waters giving a roughness to the touch.

A little practice in the physical and simple chemical examination of water would soon enable us to form a fair opinion of samples of water, or at least familiarise us with the chief characters by which waters may be distinguished as grossly contaminated. It does not, however, give us any information as to the number and kinds of bacteria present, and this is the most important part of an examination of water.

Chemical examination of water.—*Meaning of "pure" water.* The term "pure" as applied to water is used in two distinct senses,—one in which the water is *chemically* pure and contains nothing but water; the other in which it is *hygienically* pure, and in which, although certain foreign constituents are dissolved or contained in the water, they are not in sufficient quantities to produce any deleterious effect on the human economy. The extraneous constituents of a hygienically pure water are not only harmless, but are actually beneficial. A chemically pure water is not desirable as a beverage.

Harmful gases in water.—*Sulphuretted hydrogen.*—The presence of *sulphuretted hydrogen* is usually indicative of considerable deterioration of water. This gas is known by its odour—that of rotten eggs. It is frequently found in superficial wells and in drying up tanks. In these it is formed by the deoxidation of sulphates of metals, and this deoxidation is effected by plants undergoing decay. The oxygen of the metal sulphates combines with the carbon of the organic matter to form carbonic acid, and the sulphate combines with hydrogen to form sulphuretted hydrogen.

When water containing sulphuretted hydrogen is heated this gas is evolved and recognised by its characteristic offensive smell which is that of rotten eggs. A solution of a salt of lead added to the water gives a black precipitate.

Ammonia.—For the determination of *ammonia* in water we use what is known as *Nessler's Solution,* which is a solution of iodide of potassium, corrosive sublimate, and hydrate of sodium. A few drops of this is added to the water, and if ammonia is present a yellow colour, or yellowish-brown precipitate occurs, in accordance with the amount of ammonia present. By experience we may learn roughly the amount of ammonia present from the degree of colouration produced in this reaction. If the ammonia present is small in quantity we may require several inches of water to be seen through on a white ground.

Chlorides.—Chlorides in small quantities occur in all natural waters. An undue quantity, unless explained by its coming from a saline spring or from near the sea, should arouse suspicion. The *chlorides* in water are important as indicators of the possible existence of human excretal contamination, and sometimes they form a guide as to the channel by means of which sewage gains access. Hence the importance of estimating the amount of chlorine in quantitative chemical analyses. The presence of *chlorides* is determined by acidifying water with a little dilute nitric acid, and adding a few drops

of nitrate of silver solution. One grain to the gallon gives a haze; four grains give distinct turbidity, ten grains slight, and twenty grains a considerable, precipitate. Chlorine is usually due to ordinary salt. It may be from the deeper parts of the soil, or (on the coast) from the sea, in which case there will be an excess of permanent hardness, the free ammonia, albuminoid ammonia and the total solids will be in small quantities, and in this case even a large amount of chlorine may be harmless; or the chlorine may be from pollution by animal matter, particularly urine, in which case the free and albuminoid ammonia and volatile solids (those dissipated by incineration) will show recent and dangerous pollution (*vide infra*).

Nitrates in water.—Almost all waters contain a certain amount of either nitrate of sodium (cubic nitre), or nitrate of potassium (saltpetre), or nitrate of lime (calcareous nitre). Nitre is an oxidised product of decomposed dead animal and vegetable matter. In the quantities in which usually found, nitrates are not harmful to man and animals using the water.

When water comes into contact with decaying animal and vegetable matters, their carbon is oxidised to carbonic acid gas, and their nitrogen is oxidised to nitrates, which are dissolved in the water. When this oxidation of organic matter is incomplete in wells, tanks, etc., the water is impure and may be very dangerous to use. Partial oxidation results in the produce of *nitrites*. The presence of nitrites in water is always looked upon with suspicion. They are usually contained in water that is deficiently aerated. When water is undergoing proper aeration, the nitrogen evolved out of organic matter is oxidised into nitrates, and the nitrates into ammonia, with very little formation of nitrites. An increase of nitrates and nitrites is evidence of *previous* contamination of a dangerous kind, but not proof of existing danger. On the other hand, any noteworthy increase of oxidisable organic matter calls for grave apprehension as to the quality of a water.

Nitrification, by which nitrogenous organic matter in water (or in soil) is oxidised to produce nitrates, is largely due to microbes.

Organic matter.—There is no direct method by which the amount of organic matter present in water can be determined; and it is therefore necessary to employ in its estimation the known tendency of organic matter to decompose into nitrites, nitrates, and ammonia. The *free ammonia* occurring in water represents the ammonia combined with nitric, carbonic and other acids, and also what may be derived from urea of urine or other easily decomposable nitrogneous substances, if they are present. In a chemical analysis of water, after ascertaining the amount of free or saline ammonia by distillation, the residue left is used for estimating what is called *albuminoid ammonia*, which is done by a somewhat complicated process we need not describe here.

Nitrogenous organic matter.—There should be practically no *nitrogenous organic matter* in water, and if there is much *free ammonia*, the smallest amount of albuminoid ammonia should be viewed with suspicion.

Animal matter.—*Animal matter* should always be regarded as injurious to the quality of a water, especially if human excrement is the source of the animal matter.

It is most important that all drinking water be free from decomposing organic matter. In such a state organic matter is almost invariably associated with micro-organisms, which, amongst others, may contain the germs of typhoid fever, dysentery, and cholera. This is particularly liable to occur if the excrement of persons suffering from these diseases gains access to the water, and we know that there are many ways in which this can occur.

Limits of impurities allowable.—It is useful to possess some standard as to the admissible limit of the various constituents of a *first class water*. With reference to such a standard we would state that only slight traces of the following substances are admissible :—Nitric and nitrous acids, ammonia salts, metallic salts, organic matter, and sulphuretted hydrogen. It is extremely rare to find all of these substances absent, yet anything beyond a trace should be looked upon with suspicion.

Lead.—No drinking water containing lead, even if only a trace, should be used; it is always dangerous, and the particular sample analysed may not show the maximum quantity of lead present.

A few drops of sulphuric acid added to water containing lead give a white precipitate which is insoluble if more acid is added. Solution of sulphuretted hydrogen or ammonium sulphide gives a black precipitate of sulphide of lead.

If a water gives negative results in its physical examination we may ordinarily regard it as of good quality. If we are at all doubtful as to its characters, we should have it subjected to both a qualitative and quantitative chemical examination. We would repeat that whilst the senses are unreliable judges in estimating the wholesomeness of a water, on field service, when daily moving from one place to another, the physical examination is our main guide. In standing camps the case is different, there the water-supply will, of course, be thoroughly tested, as a matter of routine, by sanitary or other medical officers.

Physical characters of good water.—Good water should be clear, colourless, or have only a faint bluish tint when viewed through a depth of two or three feet. *Greenish* water may not be bad, but *yellowish or brownish waters* are impure as a rule. Water should be bright and sparkling. This shows that it contains the necessary gases to make it palatable—oxygen and carbonic acid. The taste should be pleasant.

There should be no smell, and it should dissolve soap readily, *i.e.*, it should not be hard. There should be no visible sediment. A water that possesses these characters is probably drinkable. But it may not be so, for the most dangerous agents in water are disease-germs, and these are invisible, and may exist in vast multitudes without being known to our senses.

Bacteriological, etc., examination of water.—*Living organisms in water.*—Living organisms of all sorts and descriptions, both vegetable and animal, are frequently met with in water. Their presence naturally indicates the existence of a suitable food, which food is chiefly organic. They do not of themselves, however, entitle us to absolutely condemn the water in which they are found, yet a water containing an abundance of life must be regarded as inferior and less desirable, than one that is clear and comparatively free from living organisms.

Fungi.—The microscopical and bacteriological examinations, therefore, form important supplements to the physical and chemical examination of water. Of the *vegetable* organisms *fungi* are the most important. The chief forms of fungi met with in water as far as

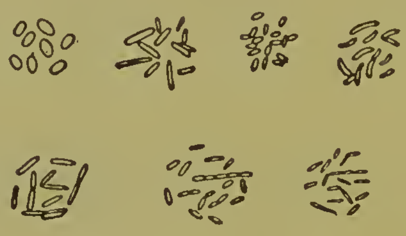

FIG. 12.—Groups of the more common bacteria found in water.

public health is concerned are bacilli (which are not commonest), vibrios or spirilla, and micrococci,* all of which require as food organic carbonaceous matter, nitrates which they reduce to nitrites, a trace of phosphates, and usually oxygen. Practically no natural water is free from these vegetable germs.

The bacteriological examination of water does not consist of the simple process of taking a drop of the sample, putting it between a slide and cover slip, and then under the microscope. Disease-germs in water-supplies are practically never in such numbers as to be found in this way. A certain small quantity of the water has to be added to nutrient media and then kept at the most suitable temperature for their multiplication. It is usually found that at the end of a certain time, varying from 8 hours to some days, several varieties of organisms form colonies mostly harmless. When the characters of the colonies are characteristic of one or more forms of disease micro-organisms, these are examined and sub-cultures made, and so on, the process being repeated until one or more varieties of the germs have been isolated and identified.

A complete bacteriological examination tells us the number of organisms present in a definite small quantity of water, the presence of any organisms of sewage contamination, and occasionally the presence of the specific organisms of disease.

* See *Elements of General Bacteriology*, PART IV.

The number of micro-organisms in different kinds of water varies considerably, but on the whole corresponds with, and gives an approximate estimate as to, the degree of impurity. Yet all vegetable germs in water are not harmful; some indeed exercise a purifying influence by feeding on, and bringing about a disintegration of, the organic impurities contained in the water. This is the case with the crowds of bacteria lying in the gelatinous film resting on the superficial layer of sand in the filter beds of public water-supplies. Certain forms of micro-organisms split up the nitrogenous (animal) matter, and convert it into ammonia, nitrites, and later on, nitrates. Some germs are related to ordinary decomposition processes, whilst others may be the seeds of specific diseases.

The importance of a thorough acquaintance with the life-history of the individual micro-organisms by those investigating water-supplies is well recognised. For example, by such means the bacillus of typhoid fever can be distinguished from the several varieties of bacilli met with in excreta simulating it, the different varieties of the bacillus of dysentery can be differentiated from the typhoid oue and those resembling it, and both these from innocent bacilli like them; the spirillum of Asiatic cholera can be distinguished from other comma-shaped organisms; and inasmuch as the presence of any one of these disease-producing microbes in a water-supply is an indication of contamination with discharges from persons with the disease, such water should be condemned for drinking purposes.

The object of a bacteriological examination is to determine whether the water is one which can be used with safety at the time, and subsequently. In the early days of the bacteriological examination of water, it was thought that the detection of such microbes as those of typhoid fever and cholera iu water, would become an operation of great importance and easy to carry out. This hope has not been realised; the difficulties connected with such investigations of water makes them of little use to us from a practical point of view in our every-day examination of water-supplies. These microbes can, of course, be detected and isolated, and when we suspect specific coutamination of water by any particular microbe, we attempt to effect such isolatiou and ideutification.

Bacterial indicators.—Formerly we chiefly relied on the numerical count of colonies of microbes cultivated on nutrient media from the water under examination. The unreliability of simple enumeration of colonies of bacteria has, however, necessitated the devising of some more certain method of determining the quality of a drinking water, and for this purpose the use of *bacterial indicators* has become generalised, and is undoubtedly of great value. The worst form of pollution to which a water can be subjected is that of human excreta. We are bound to recognise human excreta, of the diseased or healthy, as potential vehicles for the causation of disease. To detect whether there has been human excretal contamination is one of the chief objects of the water bacteriologist of the present day. Several microbes have been chosen as fulfiling the requirements necessary for showing that there has been such contamination. These requirements are :—The microbes should be abundant in the substances for which its presence serves as an indicator; it should be absent or practically absent from all other sources; it should be easily isolated, and numerically estimated, and its characters should be definite and not liable to variation. It is of no importance whether the microbe used as an indicator is innocent or otherwise.

The special nutrient medium that is used to detect the presence of bacteria indicators is what is known as bile-salt-glucose-peptone-litmus solution,* definite small quantities of the water to be tested being incubated in test tubes in this at 105° Fahr. for 48 hours. In this solution the common colon bacillus and *Bacillus enteritidis sporogenes* produce acid (as shown by causing the purple colour imparted to the solution by the litmus to become blue or bluish) and gas (which collects in a small inverted glass tube placed in the test tubes), while streptococci, staphylococci, and the bacilli of typhoid fever, dysentery, and cholera produce acid only. By a series of sub-cultures and the use of various sugars (glucose, lactose, maltose, mannite, dulcite, etc.,) which are fermented (thereby producing acid and gas) by particular microbes and different strains of microbes, the actual germs present may be worked out in a bacteriological laboratory.

Common colon bacillus.—The common colon bacillus is now generally accepted as the best indicator of harmful contamination. "There is no evidence or observations which have ever shown that the bacillus coli, reasonably defined, is present in any numbers in sources which have not been exposed to some form of fæcal contamination It is a reliable indicator of excretal contamination. It indicates excretal but not necessarily human excretal contamination. Its value as an indicator of harmful pollution depends both on the completeness of its attributes as compared with the characteristic organism of human excreta, and upon its numerical presence; the more nearly its characters are in accord with those of the excretal bacillus, the greater its value and the fewer required to be present to establish evidence of pollution."

Bacillus enteritidis sporogenes.—Another bacillus called *Bacillus enteritidis sporogenes* "has been largely used as a test for excretal contamination of water. It is spore-bearing, and it is the spores which are used for its detection; owing to the prolonged powers of resistance, the presence of the spores shows contamination by no means necessarily recent, but rather at some previous date."

It is, of course, necessary to have some sort of standard to work with when using these organisms as indicators; such a standard is used by experts only as a general guide, and is not taken as a hard-and-fast basis of opinion as regards the wholesomeness of a water.

It is impossible to make any definite statement as to the number of bacteria permissible in a wholesome water; the kind of bacteria and relative number of each species are of much greater importance than the total number present. "Estimation of the quality of water based only upon counting colonies of bacteria in plate cultivation are of little value, but other things being equal and constant, a small number of organisms tend to indicate a small degree of organic pollution and conditions unfavourable to the multiplication of bacteria."

The standard for surface water is ten times as slack as that for deep water.

The ordinary bacteria of water are of little significance except when present in excessive numbers as they are not harmful. They consist of what are known as *flourescent bacilli*, some of which liquefy gelatin and some do not; ordinary colour-producing bacteria, and the germs of ordinary air and soil.

Typhoid fever and cholera bacilli are rarely found in water, for by the time the disease has developed, the germs have disappeared, as they only live in water a few days. It is seldom that we have the opportunity of examining water that really causes an outbreak of either of these diseases; still rarer is it to find true dysentery bacilli in water.

Investigation of sources of pollution of water.—In attempting to ascertain the source of pollution of water from wells or other collections of water, the water itself is first subjected to a careful physical, chemical and bacteriological examination. The source itself, its immediate surroundings, and the whole area drained, are also inspected. When a contaminating source is suspected which

* So named because it contained sodium taurocholate (obtained from bile), glucose (grape sugar), peptone, and litmus solution.

may be a hundred yards or more from the water, then either a solution of common salt, chloride of lithium, or a richly coloured material, called *flourescin*, is thrown into this source, and the water under investigation is later on tested chemically for chlorine from the salt, for lithium by evaporating the water and flaming the residue, when a crimson flame will be seen by the eye or by the spectroscope; flourescin (resorcin thallan), which is an orange dye having a peculiar green flourescence when in water, is at once recognised. Flourescin is superior to any of the other indicators except lithia, because the water has not to be previously tested for its presence. With reference to the finding of the chlorine, the water will naturally contain a certain amount, and that amount has to be first ascertained before using this test. If there is any material difference in the chlorine before and after using the salt, one source of the contamination is definitely shown. There may of course be several sources of pollution in the same water.

Animalculæ, etc., in water.—Of the animal kingdom the *Infusoria* and *Rhozopada* are abundantly represented in pools, tanks and rivers. They are themselves harmless, but point to an existing pabulum of organic matter in the water, which in many cases is in such quantity as to lead to serious contamination. *Hydrozoa* and *Rotifera* are frequently present in good water. *Nematodœ* are aften found in impure water. In this latter order are included the eggs of round and thread worms (which may inhabit the alimentary tract of human beings), and the embryo of the guinea-worm. *Leeches* are frequently met with in water. They are often dangerous from the bleeding they may cause from the throat, or even from the stomach when they gain access to that organ. The absence of fish and molluscs in perennial rivers and tanks denotes bad water. Water fleas, *Cyclops*, *Daphnia*, etc., are found in apparently good water.

E.—Purification of Water.

There are very few waters that do not require some form of purification before being used for drinking purposes. Rain-water (if collected pure), distilled water, water from mountain streams and from springs at a distance from human habitations, may be used without any preparation; so may as a rule the water supplied by water-works, for in this case water has been tolerably well fitted for all purposes by previous filtration through sand and gravel or other means before distribution. In all other instances the water should be thoroughly filtered, or better, boiled and filtered.

There are four general methods of purification of water:—

Natural.—Subsidence of impurities, oxidation, action of vegetation, fishes.

Physical.—Distillation; heat—including boiling in special water sterilising apparatus, and boiling in small utensils.

Mechanical.—Filtration (in many cases this is also partly chemical)

Chemical.—By the action of agents that act chiefly mechanically, partly mechanically and chemically, and by germicidal bodies.

Natural methods of purification.—*Action of fishes and plants.*—*Fishes and some of the larger water plants* ordinarily take no small share in purifying water. Plants act chemically by aiding the oxidation of any organic matter present.

Subsidence of impurities.—By the physical process of *subsidence*, the suspended solid matters finding their way into tanks, etc., gradually

sink to the bottom. This is one of the most active of the natural purifiers of large bodies of water. The influence of this factor is fully demonstrated by removing a little of the silt and filth from the bottom of a tank, or a large well in use, that has not been cleaned for some time. The water of tanks and rivers, during the rains, contains a large amount of fine clay; this gradually subsides, and, in finding its way to the bottom, carries with it much of the suspended organic matter.

Oxidation by air.—With regard to *oxidation*, we have already alluded to the action of air-oxygen on contaminated waters. All natural waters contain a certain amount of dissolved oxygen. This oxygen has the power of oxidising and rendering innocuous, to some degree, most of the suspended and dissolved organic impurities of water. Water in motion contains more oxygen than that which is stationary. In moving water the impurities are more rapidly and repeatedly brought into contact with atmospheric air. Oxidation rapidly removes sulphuretted hydrogen, offensive organic vapours, and a certain amount of the dissolved organic matter.

It is the oxygen contained in river water that helps so considerably in the purification of river waters. The water of rivers and streams with steep falls and rugged beds dissolves a large amount of oxygen, and may thus get rid of a considerable degree of pollution.

Various forms of vegetation in rivers and streams are active in purifying waters by giving off oxygen in a very active state. It is probable that the oxidation that goes on in rivers is a chemical process begun by the action of sunlight. Muddy rivers impenetrable to bright sunlight are but little affected by this process of oxidation. All the natural processes, except when combined under the most favourable circumstances, are insufficient to deal with the degree of pollution going on in most Indian rivers.

Chemical methods of purification.—Chemical purification of water is old and time-honoured; many forms have been employed, the principles being to precipitate suspended matters, remove hardness, or oxidise any organic impurities present.

Alum.—Various chemical agents are used in effecting the *precipitation* of impurities. *Alum* has been used in India for precipitating the impurities of water for many centuries. The aluminous salts are very serviceable in removing suspended organic matter if carbonate of lime is contained in the water. The alum causes a flocculent precipitate of hydrate of alumina, which takes up the colouring matter of the water and abstracts the solid matters in suspension, all gradually finding their way to the bottom. Alum to some extent also acts on many forms of bacteria in water, but it does not appear to affect the germs of typhoid fever or cholera.

Abont 6 grains of crystallized alum are required to the gallon. Muddy water is readily cleared in this way. The addition of 5 grains of lime to the gallon, after the alum, clears the water. It is doubtful, however, as to whether alum has much effect on dissolved organic matter. The action of alum on a turbid or muddy water is very striking. When alum in this way is to be added to drinking water, it is desirable that this addition be undertaken several hours before the water is used, to give time for the precipitation to be effected. A simple way of using alum is to put a lump of it into a cleft of a clean split bamboo, and stir it round in the water ; the sediment will soon sink to the bottom, and the clear water may then be drawn off. This clarification does not render the water safe for use.

Action of permanganate of potassium.—Water containing organic matter may be at least partly purified by adding a small quantity of permanganate of potassium to it. This salt contains an excess of oxygen which combines with the organic matter present to render it harmless. It is a powerful oxidising chemical salt, and is at times exceedingly useful in ridding water of the dangers associated with contained organic matter. The action of the alkaline permanganate on organic matter varies with the nature of the impurity. In some cases much of the animal and vegetable organic matter is rendered innocuous, in others the action is somewhat uncertain. The use of permanganate of potash frequently gives rise to a yellowish tint in the water, due to finely-divided peroxide of manganese in suspension This does not interfere with the wholesomeness of the water. A little alum will carry down the suspended peroxide. Filtration effects the same object. There appears to be no doubt that if the impurity of water depends upon organic matter, the use of the permanganate solution considerably reduces the dangers associated with its consumption. When a little solution of permangante of potassium is added to pure water, it gives the water a purplish colour, which colour is lasting. If organic matter is present in the water, however, the purple tint is soon lost. *Condy's fluid* * acts in the same way as permanganate of potassium.

The permanganate attacks the organic matter present in the water on which microbes feed and probably acts deleteriously on the germs themselves. The organic and other suspended matter in the water is precipitated. Pure water will retain the pink hue given to it by permanganate for 24 hours.

Permanganate of potassium is specially valuable in getting rid of the unpleasant odour of certain waters, particularly those of stagnant tanks and surface wells. It readily removes the smell of sulphuretted hydrogen, and also the peculiar offensive odour of impure water that has been kept in wooden casks and iron tanks.

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* Condy's Fluid is a solution of permanganate and manganate of sodium.

Whenever permanganate of potassium is used in this way for purifying water for troops it requires the supervision of a European officer, who, however, when Native troops are to use the water, should take no active part in carrying out the process

If this is to be done on the line of march or on manœuvres, it is best to send the water party on 12 to 16 hours ahead, so that the permanganate will have had time to act and all suspended matter have been precipitated by the time the main body arrives.

The usual directions for the use of permanganate on a small scale in the case of any foul-smelling or suspected water are :—Add a solution of a permanganate of potassium crystals (1 in 500 of water), teaspoonful by teaspoonful to three or four gallons of water, stirring constantly. When the least permanent pink tint is perceptible, stop for five minutes; if the tint is gone, add 30 drops, and then, if necessary, 30 more. Now allow to stand for six hours; and then add for each gallon six grains of crystallised alum.

Disinfection of Wells and Tanks with permanganate of potassium.—This is now largely practised in India, especially during cholera periods. When the quality of a well water is suspected, one part of permanganate of potassium is to be added to 4,000 of the water. A greater strength than this is often required in very impure wells. In an ordinary well of, say, 10 to 12 feet in diameter about 4 ounces of permanganate is sufficient, and for a small well of 4 to 6 feet in diameter 2 ounces. The 4 ounces are first dissolved in a bucket or other vessel of water, the bucket is then sunk to the bottom of the well and suddenly drawn up again to the surface, and this is repeated several times until the solution has mixed uniformly with the well water. Where caste prejudice exists, the permanganating should be carried out by a Brahmin or other selected person, under supervision. It is better to do this in the evening after the people have ceased using the water for the day, so as to allow time for the permanganate to act and the water to lose its deep purple colour. If any colour still remains, a few grains of alum to the gallon added to the water clears it rapidly.

A stock of permanganate of potassium crystals is a very useful addition to the articles required in camp and jungle life, and to those of troops proceeding on field service.

Slaked lime is also used for disinfecting wells and tanks, about an ounce being used to every 6 or 7 gallons of water About 20 pounds are required for a small, and 40 pounds for a large well ; it should be thoroughly mixed with the water and time allowed for the precipitation of the organic matter to take place.

Lime-water reduces ordinary hardness of water.—Very hard water is softened by the addition of *lime-water* when such water is required for drinking purposes, and by the addition of *crude carbonate of soda* when the water is to be used for washing clothes.

Ozone has been used in late years as a steriliser of water-supplies on the Continent of Europe, the gas being generated by electricity and forced up through the water descending in water towers

Copper sulphate or chloride has of late years been largely used for restraining the growth of algæ and other aquatic plants of low order in reservoirs and tanks—1 part to a million parts of water being sufficient for the purpose, and in this strength is free from danger. The copper is precipitated as a basic salt and the water so treated is often rendered clear and bright. In this strength it has no decided effect on the bacteria of water. To be effective for this purpose a strength of 1 to 10,000 is required, which strength is decidedly objectionable in water-supplies. The question as to the use of these soluble copper salts in public water-supplies is still *sub judice*. It would appear that strips of bright copper placed in utensils used for domestic storage of water for 24 hours is capable of restraining, and, in some instances, of actually killing the bacilli of typhoid fever and cholera.

Various chemical preparations have been used for the purification of water, all acting as destroyers of microbes with greater or lesser rapidity. The most useful of the germ-destroying tablets yet employed is the *bisulphate of sodium*, if it is allowed half an hour to carry out its office. The tablet that was used during manœuvres at home consisted of 15 grains of bisulphate of sodium sweetened with saccharin and flavoured with oil of lemons. This makes a pleasant drink.

These tablets kill cholera and other germs quickly, and for actively moving troops, light movable columns, forced marches, and for cavalry, they are a useful addition. One would strongly recommend that these tablets get an extended trial during manœuvres.

Iodine has been used as a chemical steriliser for drinking water for troops on field service. The iodine is set free from a mixture of iodide of potassium and iodate of sodium in tablet form, the iodine being set free by a weak acid. As recommended by VAILLARD it consists of three different kinds of coloured tablets. No. 1 tinted blue, contains 0·1 gramme of iodide of potassium and 0·016 gramme of iodate of sodium. No. 2 tablet which is tinted red, contains 0·1 gramme of tartaric acid; No. 3 which is white, contains 0·12 gramme of sodium hyposulphite. The potassium and sodium tablets are crushed and dropped in a little water giving rise to a brownish fluid, the colour being due to the iodine which is set free. This kills all germs in 10 minutes. The subsequent use of the white tablet, hyposulphite of sodium, removes the iodine and renders the water potable. VAILLARD arrived at the conclusion that for troops on the march, boiling and filtering are not practicable measures, and under such conditions, he pins his faith to chemical sterilisation by *iodine*, using his red, white and blue tabloids for his purpose. A modification of these is found in NESFIELD'S tabloids or powders.

We used NESFIELD'S powders in passing through a cholera district going to and returning from the Agra Concentration of 1907, but our limited experience of them does not justify any conclusion being arrived at as to their properties in sterilising a water specifically polluted and containing cholera vibrios. With Native regiments it is certainly a huge undertaking to use these tabloids or powders for all water

consumed, and the chance of some men getting water that has not been sterilised into their bottles is not inconsiderable. The effects on the potable qualities of the water is insignificant—that is, it induces no taste, and only a very faint odour of iodine, which would scarcely be noticed by those unaware of its presence.

Possible special use of Nesfield's iodine tabloids.—With reference to Nesfield's powders (or tabloids) one would suggest making these up into tiny portable tabloids in such a way that the soldier received a packet of, say, 100 each of the three kinds (A. B. C.); one set of three taloids being sufficient to sterilise the contents of one water-bottle, so that it would only be necessary to add these three under the prescribed conditions, to drinking water of doubtful quality. These would last each man at least 15 days.

NESFIELD has also advocated the use of *liquified chlorine* contained in lead-lined iron cylinders to purify water. He recommends that about 150 grains of this be set free into 8 gallons of water and subsequently dechlorinated by sodium sulphate. This for troops on field service is scarcely practicable, for apart from the fact that the complete sterilisation of the water is not always secured in this way, there is the difficulty of carrying these cylinders, and the process is too slow and complicated for the conditions of field service.

Bromine has likewise been used, about one grain, contained in small glass tubes being added to a pint of water and allowed to act for five minutes and then debrominised by small tablets of sodium sulphite. This is a method that promises well.

Hypochlorite of calcium has been used in the Austrian Army to sterilise water in a strength of less than half a grain to a quart of water, but it is difficult to make up into tablets and gives the water an unpleasant taste.

Physical methods of purification.—*Sterilisation of water by boiling.*—In order to render our safety from micro-organisms practically absolute, it is necessary to have our drinking water boiled or reliably filtered. Boiled and filtered water, preserved and distributed in sterilised containers is one of our greatest auxiliaries in the prevention of disease in India. In fact, nearly all the terrors which micro-organisms are justly capable of inspiring, melt away when we remember that we can effectually combat them by heat and filtration. These are the two most effective measures which can be taken in avoiding disease from specifically contaminated water. By insisting upon these operations being systematically carried out, we can render ourselves independent of the purity of our water-supply, the safety and wholesomeness of which it is otherwise beyond our power to control. The insipid taste given to water by boiling is remedied by the addition of a little lime-juice or sugar, or both.

Essential effects of boiling water.—Boiling, when properly carried out, effectually kills all disease microbes, removes all temporary

hardness, destroys the bacteria of specific diseases and renders harmless all dissolved organic impurities in water. Some of the organic matter which may be contained in the water is carried down by the precipitated carbonate of lime. To be effectnal, however, the water should be boiled for at least five minntes, or boiled for a less time under superheated steam pressure, so as to raise it to 230° Fahr., at which temperature all possible disease-germs are killed in a few seconds.

Boiling robs water of the gases it naturally contains, and in this way renders it flat and insipid. Boiled water should be nsed as soon after boiling as practicable, as boiled water readily takes up microbes from the air. Boiled water should be stored in clean vessels, and excluded from all possible sources of contamination. Cooling may be expedited by placing a clean wet rag around the vessel.

Aeration of boiled water.—To make boiled water palatable it should be aerated subsequent to boiling. This is effectually done in the McNamara filter, or any one of the porcelain or infusorial earth filters. In the absence of any of these, it may be passed through an ordinary sieve, previously "fired" if of metal, otherwise soaked for some time in boiling water. Empty kerosine oil or biscuit tins with perforations in the bottom, suspended over a storage tank, effect this.

Where the quality of the water is doubtful and on account of want of time we cannot supervise its purification personally, it is safer to use tea or coffee—the boiling of the water in making these kills all germs. The stored drinks must not be subject to any kind of contamination.

There are various disadvantages associated with the boiling of water, the more important of which are—its expense, the water is rendered tasteless and flat, it loses its natural gases, the water has to be cooled before it is drunk, and it is very difficult to carry out on a large scale except in special apparatus.

Since the South African War the question of devising a satisfactory water steriliser for field service has received much attention. McCulloch says that as the result of experience gained in recent expeditions, probably more than one method of sterilisation will always be required to meet the variety of conditions obtaining on field service. This refers to a large force or forces, engaged over a wide area, under varying conditions.

Portable water-sterilising carts.—Many forms of portable water-sterilising apparatus, chiefly in the shape of water-carts, have been introduced into armies in recent years. The experience of the Americans in the Philippines, and the Germans in West Africa is to the effect that enteric fever, dysentery and diarrhœa, have undergone reduction since their use. It is a well-founded assertion that the introduction of Pasteur-Chamberland filters, both in Tonquin and Algiers, considerably reduced the inefficiency and mortality due to typhoid fever and dysentery. Some of these have consisted of carts containing a battery of Pasteur-Chamberland or Berkefeld filter candles; others of a method of sterilising by boiling the water under high

pressure, so that it attains a temperature of from 220 to 230° Fahr.—a heat incompatible with the life of either adult disease-germs or their spores. A travelling water-cart with a charge of Pasteur-Chamberland candles has been used for some time by the United States' troops in the Philippines.

Various forms of portable water sterilisers are in use at the present day, chiefly for armies in the field. All the machines are designed on the principle of heat exchange, which, as applied to the purification of water depends on the fact that, with a sufficient area of metallic surface of good conducting capacity, and sufficient time, a given quantity of hot liquid will yield nearly all its heat to an equal amount of similar but cold liquid. The most popular machines of the kind in use at present in the United Kingdom are the Griffith's and the Lawrence sterilisers. In the Griffith's steriliser the water is only brought to a temperature of 173° Fahr., which is sufficient to kill typhoid, dysentery, and cholera germs. It is a very portable apparatus, weighs 100 pounds, without its case, and delivers 60 gallons of sterilised water per hour, in doing which it uses about 1½ pints of oil.

One of the chief difficulties to be encountered in sterilising water for men on the march by heat is the question of fuel. Many water-carts have been invented, especially since the war in South Africa, and a great deal of controversy has arisen in connection with the subject, and the respective merits of various methods. All the inventions are to some extent unsatisfactory on account of the bulk of fuel be carried and the large quantity required to sterilise a comparatively small quantity of water. Coal is heavy, and needs special transport which may be difficult to obtain on field service. Petrol and various kinds of oil are fairly bulky and inflammable. Recently a new electric fuel called "Thermit" has been used, and is said to satisfy the requirements better than any other fuel. "Thermit" consists of a blackish-grey powder composed of a mixture of aluminium and either ferric or ferrous oxide. When a small quantity of a re-agent such as peroxide of barium or chromium is placed on the surface of the mixture and a match applied, intense combustion arises at once and this heat has been used for sterilising water.

Qualities of an ideal sterilising water-cart.—An ideal water-cart is one that could be drawn by a horse or mule, with a means of boiling the water in a few minutes, and if possible with a means of cooling the boiled water. The fuel must be transported on the cart itself in sufficient quantity to last the company, or other regimental unit, for at least three days, boiling water twice a day. The ordinary service water-cart used in South Africa holds about 108 gallons, and, when full, weighs about a ton. Whilst the question of fuel has perhaps never been satisfactorily settled, that of cooling the water has presented comparatively few difficulties, and there are at present many forms of water-carts in which the apparatus does this.

There are many forms of heat sterilising apparatus, all those in use at the present day being based on the principle of sterilising water by means of heat exchange. The heat of the water that has been sterilised in the pipes is utilised to raise the temperature of the incoming cold water as it goes to the sterilising chamber, whilst the cold, which the water parts with, is utilised for reducing the temperature of the sterilised water. In this way the sterilised water may be discharged from the apparatus at only 10° Fahr. warmer than it enters it. There is much

probability that some special apparatus devised on the principle of heat exchange will in the future form the means of supply of a large part of our Army in the field with sterilised water. Water may be boiled in the ordinary *camp kettles* and placed in the McNamara zinc cylinders.

Where boiling has to be carried out on manœuvres or on the march, the water party should go on the day before to carry out the process and have the cooled water ready for use for the regulation containers by the time the force arrives.

In barrack-rooms of British troops with a heat steriliser, such as the Larymore boiler, after this is filled no native should be allowed to approach the water; everything further necessary should be carried out by the European soldier himself. "The tap water must be boiled in the Larymore boiler, the whistle going for 10 minutes. The boiler should be cleaned inside once a week with a scrubbing brush on a long handle by a soldier. The brush must be used for no other purpose, and kept by the non-commissioned officer in charge of the water-supply. If further cleaning is required clean ashes should be used. The Larymore boiler should be filled from a tap over it. Until this can be arranged the boiler should be filled by open metal buckets. Under no circumstances should the same buckets be used for filling the boilers and then distributing the boiled water. This is a dangerous practice. The water should be carried in covered buckets from the boiler to the large zinc receptacles (McNamara's). These should be locked. The covered buckets should be rinsed out with boiled water daily before use and scrubbed once a week with clean ashes and a small brush. This brush must, of course, be under the care of the non-commissioned officer in charge. The zinc receptacles should be scrubbed out with the same brush, clean ashes and boiling water once a fortnight. As these vessels (buckets and receptacles, are for storing boiled water, it is obvious that only boiled or boiling water should be used in cleaning them. Tap water should never be used. The man who cleans the buckets and receptacles should wash his hands and arms with soap and water before he commences his work of cleaning. Each large zinc receptacle for storing water should be provided with two white drill covers reaching to four inches below the top. "A string should be run round the edge so that the cover can be drawn tight round the receptacle. This is to keep out dirt. One cover is required for use while another is at the wash. Water in the receptacles should be pinked with permanganate of potash. We should remember that mere pinking does not make impure water pure; it merely delays bacterial growth."

The water from the zinc receptacles should be drawn off and stored in *soorahies* (one *soorahie* of two gallons capacity with a narrow neck and a tin cover for every six men). Wide-mouthed chatties into which a man can get his hand should never be used for storage of water; they are a source of danger. The date of issue should be painted on the *soorahie* and once a month all *soorahies* in use should be broken. During the month the *soorahie* should be scalded daily and washed out with permanganate of potassium solution once every week. Boiled water is sterile, so that any microbes reaching it can readily grow as they are not hindered by any natural enemies. Once water has been sterilised, every endeavour must be made to keep it pure and free from infection. The soil around all barracks is probably specifically contaminated with enteric fever, and possibly dysentery, microbes, and carried by dust to water.

Boiling is the safest method of sterilising water, and when combined with reliable filtration is also the best method. For the moment the best solution of the water difficulty on field service would appear to be to provide soldiers with water-bottles in which they can boil their own drinking water.

On field service the water should be as free as possible from all organic and inorganic impurities; it should be hygienically pure at its

source, and this purity should be maintained till the water reaches its ultimate distribution, and be likewise kept so until it is actually drunk by the soldier.

Boiling of water for field army always a serious undertaking.— Boiling water for a force is at present always a serious undertaking, and under certain cricumstances may be impossible, and when this is so, filtration may have to be relied on. It should be understood that simple mechanical filtration of impurities, producing a sparkling clear water, is not a safeguard from disease-germs.

Great difficulties were experienced by the Germans in endeavouring to provide safe water for their troops in South-Western Africa, during their campaign against the Herreros. Several kinds of filter and heat sterilising apparatus were used. Some of the filters clogged, others did not sterilise. A large type of steriliser mounted on animals was on trial, but the apparatus did not always work well, and in a country where draft animals were scarce, transport was a matter of great difficulty; eventually these sterilisers had to be confined to standing camps and hospitals. Small sterilisers were also tried with disappointing results. In the end the soldier was instructed to do his own boiling.

To sterilise water on a small scale is simple enough, and practically all methods in use—boiling, filtering, chemical processes—can do this so as to render a polluted water fit for drinking. Due attention to the details of each method is always necessary, but none of them are difficult to carry out. To supply sterilised water to a whole force on field service is, however, not so simple a matter. "The great difficulty is to supply purified water with regularity and in sufficient quantity, amid the bustle and constantly varying conditions which are inseparable from active service; and to make arrangements which will ensure that every soldier in the field can always easily obtain safe water, no matter what his surroundings may be, and so that, however great his thirst, he will not be tempted to drink any foul water he may come across."

All armies who have attempted to sterilise water in the field have recognised the foregoing facts. "Although boiling requires no special plant other than the camp kettle, yet there are many difficulties, such as the provision of fuel, the time taken to raise the water to boiling point and the time taken for it to cool; meanwhile you must control the thirst of the soldier, and in the end offer him water that is often unpalatable." *

Water-supply of Japanese in late Manchurian War.—At one time in the late war, the Japanese used a water-cart drawn by four horses, and a water boiler cart drawn by one horse, and boiled water sterilisers were used during some periods of the war. As the boiling water sterilised during the march, the soldiers had to fill their water-bottles with the boiled water. During the latter part of the war, portable sterilising filters and water boilers, fixed on the one-horse general service waggon were issued to the battalion units. Throughout the campaign the water-supply received the closest attention. When they had to get water from a stream or river, they were ordered to take it from the centre of the stream, so as to avoid impurities coming from the banks of the stream, even then the water had to be boiled before they drank it. The greatest care was taken regarding the water during night marches, when there was not sufficient light to see whether the water was pure or otherwise. The Japanese soldiers are instructed during peace times how to draw water from rivers, and how to filter muddy water. Wells which produced good drinkable water were protected by sentrics after the water had been analysed. Care was taken not to allow villagers to draw water promiscuously from a well, for fear one of them might be employed by the enemy to poison the water.

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* Major T. McCulloch, R.A.M.C., *Journal of the Royal Army Medical Corps*, April 1906, p. 44.

Refreshment Stations (with sterilised water) provided for Japanese troops during Russo-Japanese War.—Refreshment stations were established at as many points as possible on the lines of communication, and even in the area of active operations. There were two or three soldiers told off as attendants at each of these stations, and they had boiling water ready night and day. Rough benches were erected under trees in summer, and guide posts were put up at the sides of roads showing the way to these stations. In the fighting line men used their mess tins to boil water in, thus strictly obeying orders regarding water. Later when they had captured the kitchen waggons of the enemy, they used these largely for boiling water in. A special kind of filter was also at one time used (Ishiji's) in the fighting line, where no smoke was allowed, or when it was difficult to get fuel. It is said to have proved most efficient in destroying bacteria in water, and for converting bad water into purified drinking water.

The Russian soldiers likewise thoroughly understood the importance of sterilising drinking water by boiling, and during a large part of their Manchurian campaign such boiling was never omitted no matter how late the men entered a billet or bivouac, and it was emphasised that it was necessary to see that the regulation allowance of fuel was provided to each section and company for this purpose.

Mechanical purification of water—*Filtration.*—Filtration is the commonest method of purification employed. It is used in practically all water-works on the plains in India, and when the filter-beds are properly constructed and the working well supervised, the filtered water is to all intents and purposes hygienically pure.

Of the large number of filters on the market at the present day the Berkefeld and Pasteur-Chamberland, and others on the same principle, are undoubtedly the best.

The Berkefeld filter.—The essential part of a Berkefeld filter is its hollow filtering candle of infusorial earth, which latter is composed of diatoms and contains by its ladder-like and interlacing structure, a vast number of small pores. Each candle or bougie is a complete filter in itself, and if there is enough pressure it acts as such. The yield varies with the form and the condition of the water as regards suspended material, and the frequency with which the filter is cleaned. When the water is turbid, the outside of the bougie soon gets covered with a deposit, the pores get rapidly clogged and impervious to the clay particles by which the process of filtration is greatly impeded, and ultimately brought to an end. Hence it is essential that muddy water be clarified before being passed through the filter.

The candles are cleaned by brushing and sponging, and it is said that with each cleaning about $\frac{1}{1,000}$th of an inch is removed, thus re-opening the pores. Disinfection of the cylinder is effected by boiling, care being taken not to injure it by sudden changes of temperature. If suddenly put into boiling water the clyinder may crack and become useless. Usually the water from these filters is almost completely sterile. It has been recommended that all filters of this class employed

for troops should be tested bacteriologically before use. It is certain that a small proportion of these filters do not sterilise water, probably from having cracks or fissures.

When the working of Berkefeld filters is carefully supervised and receives strict attention to detail, they are quite satisfactory, and yield a water that is practically sterile. Their main disadvantage is the slow delivery when the water is muddy or contains an excess of sedimentary matter. With trained men to attend to this detail there should be no difficulty if an adequate number of filters are provided. When water is muddy or dirty, one of the most obvious requirements in their use is the straining, natural sedimentation by subsidence, or artificial precipitation by alum, of all suspended matter. Water may be rapidly strained in a large sheet attached to a wooden frame, and allowed to sag—it thus forms a sort of basin, from which the water may be collected in receivers placed below.

The *Berkefeld tap filter* is similar in principle. It is connected with the water service-pipe at D (Fig. 13), the water enters the outer cylinder G G, and passes, under pressure of the water-supply, through into the interior of the inner or filtering cylinder C C. The filtered water passes out by the pipe E. The tap F is used for flushing and washing out the filter, or for supplying unfiltered water; and the screws A A are for the joint to open the filter case for removing the internal or filtering cylinder for cleaning. This filter can be procured in various

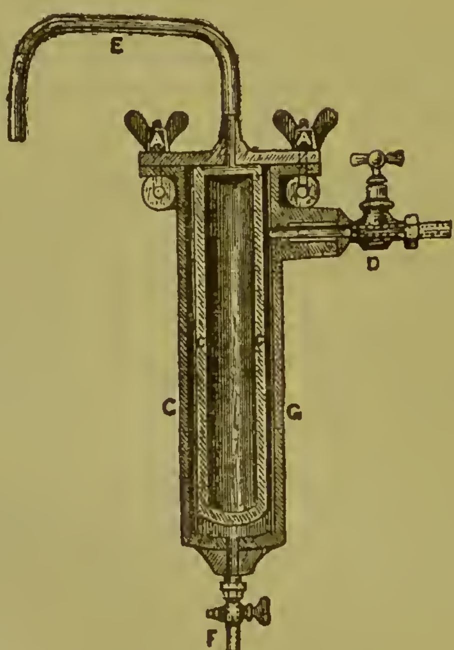

Fig. 13.—The Berkefeld tap filter.

forms from the Berkefeld Filter Company, the filtering cylinders being in all of the same material; but in the Glass Table Filters and other Drip Filters, where there is no pressure from the Public Water-supply, the rate of filtration is necessarily much slower being about a pint for each filtering cylinder per hour.

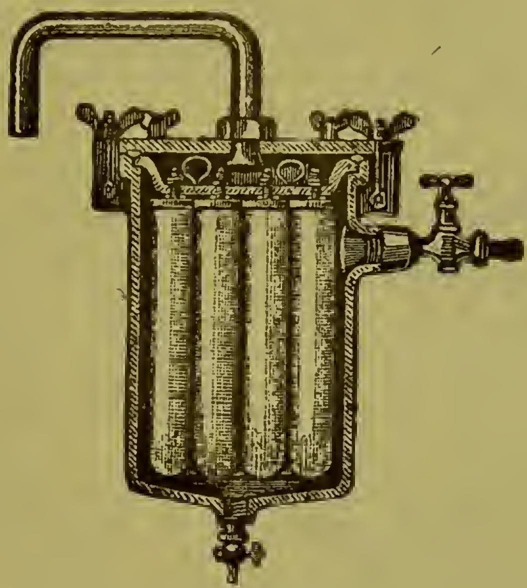

FIG. 14.—Battery of Berkefeld filters.

The Pasteur-Chamberland filter.—In the Pasteur-Chamberland filter the filtering cylinder is composed of unglazed porcelain, and in construction is similar to the Berkefeld. The yield of water is much less in the Pasteur-Chamberland filter. A battery of 12 candles under a pressure of 70 lbs. yields only about 20 gallons per hour. This filter works well for four days after which it requires sterilisation by boiling. Any great increase of pressure is said to permit germs to filter through. These, it would seem, grow by direct contact rather than by being mechaniclly filtered through.

The candles in both forms may be protected by being kept in a metal case or a glass jacket. When the filter is protected in this way, it may be attached to the water tap when the pressure from the main is sufficient to cause fairly rapid filtration. When the candle is enclosed in a metal or glass jacket a space intervenes between the two above and at the sides, where they are fixed together by a screw tap, with an opening in the centre for the passage of the nozzle. When used by travellers the encased filter may be connected with a hand-pump, a rubber tube dipping into the source whence the water is drawn for filtration. This may be a chatty or other utensil, a river or stream. In a well, the rubber tube may also be connected direct with the water and pumped up. The filtration in both is from without inwards and the supply is more rapid under equal pressure from the

Berkefeld. When a large supply is required a number of candles may be enclosed in one filtering reservoir. They may be used on a large scale also for the supply of water from wells, rivers, or reservoirs.

For rough filtration the three-chatty filter, spongy-iron, magnetic carbide, polarite, asbestos, or ordinary sand filter may be used. When used for rough filtration these filters must be regularly cleaned and boiled at least weekly. If rough filtration cannot be carried out a small quantity of alum (6 grains to the gallon) clears the water of suspended matter, and the cleared water can then be drawn off, boiled and filtered.

There is little to choose between these filters. The Pasteur-Chamberland is the stronger, but on the other hand it filters less rapidly. Both serve the purpose equally ; while the candles or cylinders of the Berkefeld filter are thicker, they are also more delicate, and, being rather brittle, require careful handling. These filters are made in all sizes, for use on a large scale and for single households, also in the portable form. No other filters are reliable; most other filters are difficult to keep clean and may even add impurities to the water.

Where the germs of infective disease are contained in the water under filtration, these germs can in four days work their way right through the filter into the filtered water. They may therefore become in time most seriously infected. Hence the necessity of sterilising by boiling these filters every four days, and when they are used in the Army, this is done as a routine matter. This boiling ensures the death of all germs that have been caught up in the filter. None of the germs known to cause disease in India can actually pass through these filters, but they can grow in the filter and eventually by their multiplication in an inward direction reach the filtered water and so contaminate it.

All sterilising filters should be taken care of by specially trained men. They are very delicate, the candles are brittle, especially the Berkefeld, and have to be handled with caution. A cracked or fissured filter is dangerous. We should note whether the rubber conections are acting perfectly and that there are no fissures, cracks, or other source of leakage of unfiltered water ; the great test is the speed of filtration ; rapid filtration is always suspicious.

Berkefeld filters made up in forms adapted to field service are now used in the armies of the United States, Germany and Austria, and were used to some extent by us in the South African War. In these forms the filter usually rests on a double acting hand-pump attached to a folding tripod, the legs of which are so arranged that they can be readily folded for transportation. The dimensions of the apparatus when folded together are 2′ by 7″ by 6″, the weight is 11 pounds, and the capacity of filtration one-half a gallon of water per minute. A Berkefeld filter without tripod attachment is supplied for hospitals on service in the Home Army and is packed in the dressing and sterilising chest. A large Berkefeld filter, containing a battery of 9 cylinders mounted in a substantial wooden frame, and intended for carriage on pack animals is also made, and supplies $4\frac{1}{2}$ gallons per minute. These were largely used in in the U. S. Army in the Cuban War.

These apparatus are of great value, but they are difficult to transport with rapidly moving troops, though most useful in all permanent camps and on the lines of communication.

The portable Pasteur-Chamberland autoclave filters, as adopted in the French Army, weighs 100 pounds. In Dahomey in 1892, and in Madagascar in 1894, they were unsatisfactory for use with marching troops, though useful for standing camps or hospitals. They were kept clean with difficulty, were heavy, and could not supply a sufficient quantity of water at a short notice at the end of a march. During the Ashantee Expedition we found that they readily clogged, were difficult to work, and had to be abandoned. In barracks these filters when properly looked after are very satisfactory. In the field, especially during an active campaign, the Berkefeld filter is the better, because of the greater amount of water it supplies. The transportation of any apparatus of this character may often be a matter of great difficulty. In cold weather and on our Frontier passes in winter, proper care should be taken to prevent their injury by freezing.

Berkefeld filters for officers' messes.—All officers' messes should have a good Berkefeld or Pasteur-Chamberland filter, with a supply of spare candles, and one of the officers should be held responsible for its being kept thoroughly clean by brushing, sponging, and occasional sterilisation, and in all respects in good working order. Except where water from an unimpeachable source is obtained, no water should be drunk that has not passed through this filter.

When travelling in the jungles, it is always advisable to provide ourselves with a portable filter of some description, for sometimes we have unfortunately to drink *jheel*, marsh, tank, or other impure water under such circumstances. The best filter for this purpose is a portable Berkefeld filter in a nickel case provided with a rubber tube and hand-pump. In the absence of any better filter an ordinary portable carbon syphon filter is better than no filter at all.

"At home a new clarifying and filtering cart is now being introduced into the service. The cart is the latest pattern iron-tank water-cart, of 108 gallons capacity, fitted with two pumps, two clarifying filters and eight Slack and Brownlow filter candles for sterilising purposes. There is a small 7-gallon tank at the back of the cart which receives the sterilised water, and fitted to this and to tubes running along each side of the cart are 12 taps from which water-bottles may be filled. A wooden locker for carrying spare parts, with a kettle for sterilising candles, strapped on the top, occupies the front part of the cart"* "The Slack and Brownlow filter is a composite filter which both clarifies and filters water, and this combination is very necessary in the field." †

Other forms of filters.—There are various other forms of filters on the market the simplest of which are the block carbon filters and the silicon carbon filters.

* *Manual of Military Sanitation*, 1907, pp. 31, 32.
† *Manual of Military Sanitation*, 1907, p. 31.

The most lasting and one of the best of this group of filters is the *spongy-iron* filter invented by Bischoff. *Spongy-iron* is a granular substance, very porous, and resembles animal charcoal in appearance. It is obtained from iron ore by calcination. The point in favour of this filter is that it splits up a part of the water into oxygen and hydrogen, the oxygen then attacks, and, to a certain extent, renders harmless any organic matters contained in the water. No matter what form of filter we use, every part of it should be accessible for cleaning.

Charcoal filters.—*Charcoal* forms the basis of a large number of patent domestic filters. If used, it should be in the form of loose charcoal pulverised into granules to prevent the water filtering too rapidly. It requires regular cleaning, otherwise it loses its efficiency in a comparatively short time. Even the most perfect of charcoal filters do not yield a completely sterile water. Charcoal filters cannot be relied on to purify really polluted water. All carbon filters soon become choked with dirt and bacteria and require to be cleansed at least once a fortnight.

In cleaning the charcoal of house filters, place it in an oven on a flat iron or metal dish, and heat it to redness, remove, and then place it in a boiling solution of fairly strong Condy's Fluid, to which some pure sulphuric acid has been added, and then dry it. Another method of cleansing carbon filters is to pass through them (1) a strong solution of permanganate of potassium (4 grains to the ounce), (2) a mixture of pure sulphuric or hydrochloric acid and water (1 ounce to 4 gallons), and (3) another 4 gallons of water which has been boiled and allowed to cool. These three processes are required before the filter is again taken into use.

Various methods of rough filtration and purification are described in *Manual of Military Engineering*, pp. 71, 72. Even a coarse filtration greatly improves water so long as the media employed cannot themselves impart impurities to the water. There are numerous devices for effecting some simple form of mechanical filtration of water on field service. Mere filtration through sand alone does not remove the injurious agents contained in impure water, although it clarifies it.

Improvised filters.—In the field it is often necessary to improvise filters, but such filters serve only to clarify water and do not remove

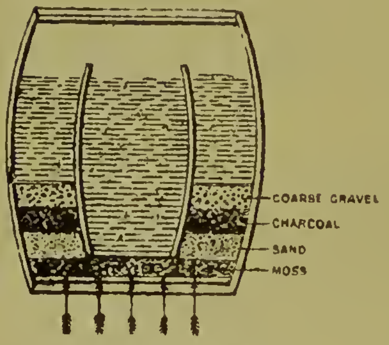

FIG. 15.—Barrel filter.

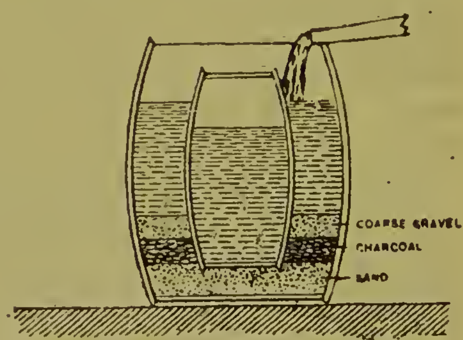

FIG. 16.—Barrel filter.

micro-organisms. After clarification, the water should be sterilised by other means, preferably by boiling.

The simplest way of accomplishing hasty filtration consists in digging a pit near the proposed source of supply, so that the water may percolate through the soil before being used. A more satisfactory method consists in sinking a barrel or box in such a pit and allowing water to pass in through a wooden trough packed with clean sand, gravel or charcoal. If two boxes or barrels of unequal size be available, one may be placed inside the other and the interspace filled with clean

sand or suitable filtering material. The outer barrel is pierced by small holes near the bottom and the inner barrel near the top, the whole being partially submerged in the water to be filtered (Fig. 15).

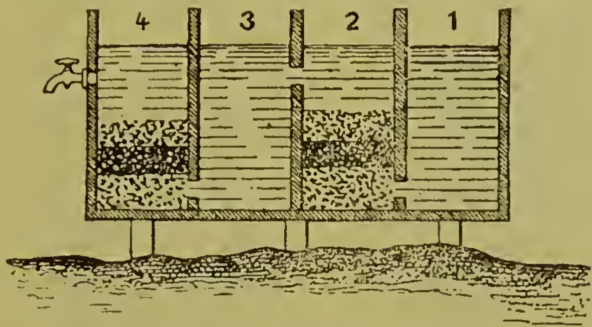

FIG. 17.—Box filter. (After PARKES.)

Where the water-supply is smaller this method may be reversed, the space between the barrels being partially filled with filtering material and the bottom of the inner barrel being removed or, better, perforated. Water is then poured in above the filtering material, whence it percolates downwards and rises to its proper level in the inner barrel (Fig. 16.)

An efficient filtering arrangement may be improvised by boring a small hole near the bottom of a suitable receptacle and partially filling the latter with layers of sand, gravel, and, if obtainable, charcoal. The water to be clarified is poured in at the top, passes through the filtering medium and is collected as it emerges from the aperture below.

Should a large box be at hand it may be made to serve both for the filtration and storage of water by dividing it into four compartments by suitably pierced partitions. Two of these spaces are partially filled with sand, charcoal and gravel, or small pebbles, the muddy water being poured in a chamber at one extremity and, after being twice filtered, removed by a spigot at the other end (Fig. 17). This method is perhaps the best for securing improvised filtration, but is open to the practical difficulty of making the partitions sufficiently tight to prevent the possibility of a leakage of unfiltered water from one compartment into another.

Two barrels of different sizes, one within the other, w th a layer of gravel and sand between them will largely help to purify an

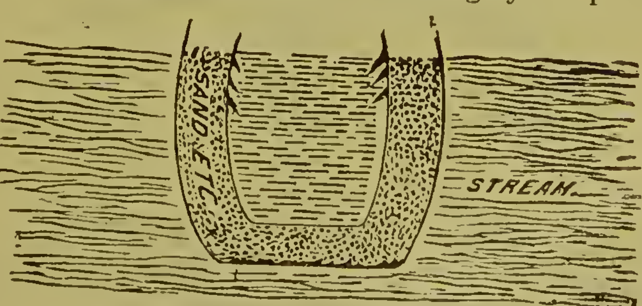

FIG. 18.—Improvised barrel filter.

impure water (Fig. 18) Or, water is taken from a river and put into a

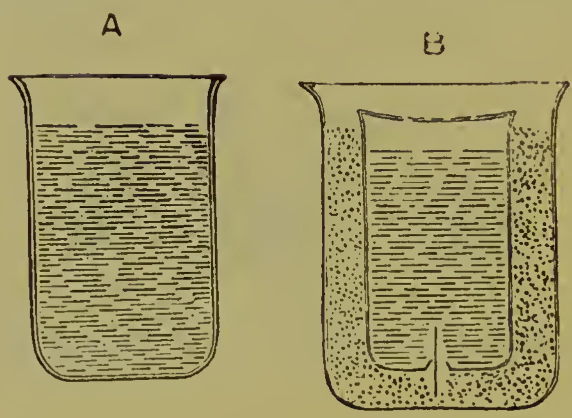

FIG. 19.—Improvised glass or flower-pot filter.

large earthenware pot (A). Alum is added to clarify it. The clarified water is then decanted into B, which consists of a small pot inside a large one, the small one having a hole punched in the bottom. The space between the pots is packed with sand, gravel, and vegetable charcoal, the water being poured into the interspace. A further filtration is carried on in another similar filter, and finally the filtered water is boiled (Fig. 19).

The Japanese used the "*Ishiji*" *filter*, which consisted of a canvas cone with two protecting arms fitting on to a collapsible metal ring. The

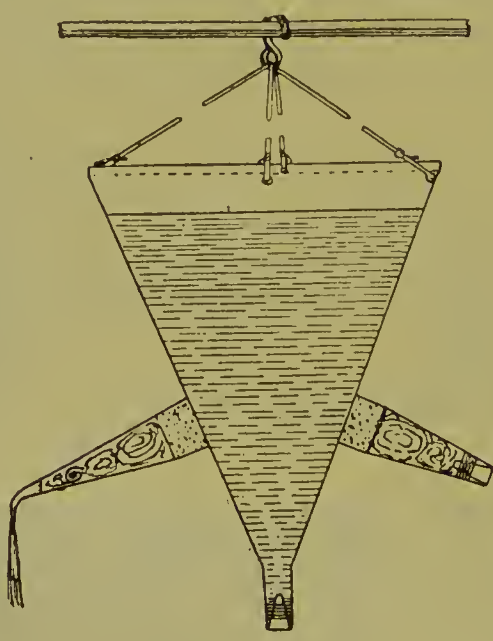

FIG. 20.—"Ishiji" camp water filter.

water was clarified by two powders and passed through a block of charcoal, but in the absence of the powders and the charcoal, wood ashes or alum answers very well.

Filters depending on sponge, cotton, and other articles liable to decay or perish, should never be used.

All filters are repositories for the impurities of water—a form of dust-bin. They take up and retain the foreign matter they have separated from the water. It should be remembered that a filter may become the breeding ground of germs, and may thus, if not kept clean, give rise to the injurious effects it is intended to prevent. They require regular and thorough cleaning. A foul filter is most dangerous, for in this state it gives to the water the impurities it has previously removed. A foul filter is worse than no filter at all; it is a water polluter, instead of a water purifier.

However bright and apparently pure a water may be, except it be from some primary spring remote from habitations, and on elevated ground, it should always be subjected to boiling and filtration, for a water may appear unimpeachable as to its wholesomeness, and yet contain the germs of disease. Filtration, and still more, filtration with boiling, lessens the keeping power of water, so that these processes should only be carried out a short time before the water is to be used.

Apart from permanganating, when the source of supply is obviously polluted, the water may be boiled or sterilised by other means, and if this cannot be done it may be actually necessary to abandon a bad water-supply. One hesitates to recommend boiling of water in the Native Army on all occasions where the quality is considered lower than a first class water, because of the difficulties to be contended with. Wood may be scarce and in wet weather damp, and so will not burn; the water has to cool; a number of additional utensils are required; and it is a great strain on hot and thirsty men after a severe march, to wait until all this is carried out. If the field equipment of the Native Army included sterilising water-carts, or other form of portable sterilisers one would have no hesitation in recommending that all water for drinking purposes should be boiled before use on field service. The common source of supply for British troops will be water sterilised by the field service filter water-carts, and whenever roads permit some form of water sterilising cart should invariably be used for them.

"Whenever filters, sterilisers, or other means of purifying water are available, two men per company should be specially selected for the purpose of providing pure water. Vessels or tanks in which drinking water is stood are to be carefully covered to keep out dust, etc., and they should be raised off the ground."*

The men must be taught never to drink unauthorised water. This rule must be rigidly enforced under all circumstances, in garrison and in the field. "Every officer is responsible that all orders affecting the health of the Army, especially those relating to water-supply, are rigidly carried out by the troops under his command. Neglect of sanitary precautions eventually results in great loss of life and efficiency."†

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* *Combined Training*, 1905, p. 46.
† *Ib.*, p. 46.

"As the health of the force depends largely on the purity of the water provided, everything possible must be done to ensure an ample supply of pure drinking water. Men must be prevented from drinking water that is not pure. Water is best rendered safe for drinking purposes by being boiled, or by the use of sterilising filters, which must be kept clean, as otherwise they become dangerous."*

"Whenever it is possible, and except when actually in touch with the enemy, it is usually possible, arrangements should be made to have an adequate quantity of sterilised and cooled water or tea ready for the men when they reach camp."

After weighing all the conditions associated with our Indian Frontier Warfare, one has come to the conclusion that boiling is the most practicable way of sterilising the water-supply for troops. One recognises this as a bold recommendation, and knowing how difficult of introduction it is, in our Native Army at least, it might be considered to be impracticable. This is not so, and one feels that until some more reliable means is discovered, the difficulties connected with fuel, extra labour, supervision, and detail of working in boiling water for *all* troops in our Army in India on field service, must be overcome somehow. Boiling and filtering apparatus can, of course, be easily used in standing camps.

The water-supply of European troops must always be under responsible European supervision, and whenever possible this should be the case also with regard to Native troops until Native officers, non-commissioned officers and men are made thoroughly familiar with the dangers attending the use of contaminated water. It is of importance to have no possible alternative water-supply for European or Native troops, for in that case the one not authorised will often be used with disastrous consequences.

No sanitary regulations can make provisions against all accidents, but apart from very exceptional contingencies it should be possible to guard against all water-borne disease in soldiers by due regard to the water-supply.

Aerated waters.—The various forms of aerated water (of which soda-water may be taken as the type) owe their sharp, characteristic taste, and sparkling appearance, to the air and carbonic acid they contain. The air and carbonic acid in aerated waters do not render these beverages less dangerous, if the water employed is previously impregnated with impurities, and it is well to remember that aerated water manufacturers of bazaars are not always particular as to the source of the water used. We have seen an instance in which aerated waters were prepared from the unfiltered water of a *katcha* tank. An analysis of this water showed an abundance of vegetable germs. The

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* *Combined Training*, 1905, p. 46.

use of aerated waters, prepared from unfiltered, impure water is very little less dangerous than the use of the impure water itself. We repeat this assertion as there is an erroneous impression abroad that aerated waters have a self-purifying property. This is a delusion. Aerated water factories should be thoroughly supervised by all local, municipal and cantonment authorities, and the filtering apparatus of these establishments carefully seen to. We feel convinced that it is much safer to use pure, boiled or filtered, drinking water, than the aerated waters generally met with in bazaars. This remark does not apply to those of large cantonments, where such manufactories are strictly superintended, but it certainly does to small towns and municipalities, where strict supervision is absent. One has never seen a bazaar aerated water factory in which there were not numerous possible channels of infection of the water used.

Aerated water is prepared as follows:—(1) Carbonic acid is generated by the action of sulphuric acid on chalk, sulphate of lime being left behind, or (2) liquid carbonic acid gas contained in iron cylinders is allowed to escape in the gaseous form into bottles containing the water to be charged. The carbonic acid is forced into the water which dissolves about five times its volume of the gas. It is merely a solution of carbonic acid in water under high pressure. Aerated water is sometimes incorrectly called *soda-water*. *Real* soda-water has 30 grains of bicarbonate of soda to the pint, and should only be used medicinally.

Where water has to be stored in the factory the cistern should be kept covered and accessible only at the tap. The cistern should be cleaned out every fortnight. Disease microbes are killed in all well-made aerated waters in course of time. The minimum period in which this is effected for all germs is probably about a week. Therefore all aerated water, unless made from boiled water or water that has been passed through an efficient sterilising filter, should be kept a week before use. This means that either the water should be reliably sterilised, or that a large stock of bottles should be in use, and the filled bottles properly arranged so as to issue the week old ones only.

All aerated water factories should be subjected to frequent inspections as regards the arrangements for sterilising the water used, for washing the bottles, the quality of the various syrups employed in making different beverages, sanitary state of the premises, position and condition of the latrine (if there is one), etc.

Ice.—As a considerable quantity of artificially prepared ice is consumed in India, it may not be out of place to make a few remarks concerning ice. *Natural* ice results from the freezing or crystallization of rain water or snow. On melting it yields an exceedingly pure water. During the freezing process it gets rid of the gases, most of the mineral and much of the organic impurities contained in the water previously. The absence of gases and all mineral matter renders it insipid and devoid of that freshness and sparkle so much appreciated

in wholesome water. The absence of saline matter renders it soft. Artificially prepared ice may also yield pure water, but should the water from which it is prepared be of doubtful quality, the possibility of contamination should not be lost sight of. Any germs in the water remain in it when frozen.

Ice should be made from the best available water, and when the water is not from a reliable public supply of proved wholesomeness, it should be sterilised by boiling before being used. If filters are in use in ice factories, they should be inspected by some responsible authority. The ice should also be periodically analysed. The freezing of water does not destroy disease-germ—it temporarily suspends their vitality, which is renewed when the ice liquefies once more, and these germs can then multiply. Ice made in bazaars is often highly impure and may contain the germs of disease, such as those of typhoid fever, dysentery and cholera. One has analysed ice manufactured from the water of a marsh pool containing 90 grains of organic matter to the gallon, and swarming with bacteria.

Ice for sick, wounded, and sunstroke cases.—When a field force is within a reasonable distance of the line of railway in hot weather, the necessity of getting up a supply of ice for the sick and wounded, and for possible cases of sunstroke, should not be forgotten.

How to keep water cool without ice.—Although it is somewhat doubtful as to whether the general use of ice to cool beverages under ordinary circumstances is an advantage to health, there is no doubt that a draught of cool pure water is exceedingly refreshing to the thirsty in hot weather. Water may be kept cool without the aid of ice by the following simple plan Place several bottles of water, covered with straw, in a coverless perforated box or in a basket. Sprinkle water over the straw every now and then, so as to keep the straw constantly damp, and have the box or basket suspended and swung to and fro. The dry heated air, coming into contact with the bottles, causes the sprinkled water to evaporate In this vaporization the heat of the water in the bottles is abstracted.

Milk infection from contaminated water.—Another item we must notice here is the dilution of milk by bazaar or village milk-sellers (*gowallahs*). That these men adulterate their milk with water is notorious. The water chosen is often from some shallow polluted pool, close at hand, or from surface wells, etc. During seasons of epidemic typhoid fever, diarrhœa and cholera, we have no hesitation in recommending the use of condensed milk in the absence of fresh milk of reliable quality. There are now many instances on record where the dilution of milk with impure water has led to outbreaks of epidemic disease. One has recently investigated the milk supply of a garrison consisting of four Native regiments, and demonstrated that every 100 parts of so-called milk contained 51 parts of water. For further remarks on milk-borne disease see article on *Milk* in the section on FOOD.

AIR AND VENTILATION.

A.—AIR.

Air is the prime necessity of life; the quality of the air breathed has an important influence on the state of the health of troops as on all other people, and it is no exaggeration to state that the impurities in the air of barrack-rooms in cantonments and in tents on the march, during manœuvres, and on field service, are answerable for a great deal of sickness. Progressively increasing evidence tells us that a vast amount of sickness in our Army in India and in the field arises from impure air. A brief consideration of the facts in connection with air and ventilation will help to explain why impure air is so deleterious to health.

Before we can properly understand how impure air affects the health of troops it is necessary to have an elementary knowledge regarding the anatomy and physiology of the organs of respiration and circulation.

Organs of respiration.—The organs of respiration include the *mouth*, *nose* and *pharynx*, the *larynx*, the *trachea* or *windpipe* and *bronchi*, the *lungs*, and the *chest walls* or *thorax*.

The mouth.—The cavity of the mouth is bounded on each side by the cheeks, the floor is formed by the tongue, and the roof by the palate. The front portion of the palate is hard, consisting of a bony plate, and is termed the *hard palate*; the back part is soft, consists of a thin sheet of muscle and mucous membrane, and is called the *soft palate*. The soft palate carries a prolongation termed the *uvula*.

When the soft palate is fully depressed it divides the mouth from the pharynx. When it is drawn up over the posterior openings of the nose (*posterior nares*) it shuts off the cavity of the nose from the pharynx.

The nose.—The cavity of the nose is divided into two chambers by a central partition. Each chamber is partly sub-divided into three smaller chambers by three delicate scroll-like bones, the *turbinate bones*. The cavity of the nose opens in front by the nostrils or *anterior nares*, behind into the pharynx by the *posterior nares*.

Both the mouth and the nose are lined by a highly vascular mucous membrane so that air passing through them is both warmed and moistened before it enters the lungs. The upper part of the nasal cavities contains the olfactory or smelling cells, which are highly developed and modified epithelial cells brought into communication by fine nerve fibres with the olfactory nerves, which are the nerves of the sense of smell. The air should naturally be conveyed to the lungs through the nose, and not through the mouth. The bones within the nose are so arranged that they act as a filter.

The larynx.—The *larynx* is the organ of the voice. In shape it is something like a small triangular box, situated in the upper and front part of the neck, between the mouth and trachea or windpipe, and just behind the tongue. It is chiefly composed of gristle or cartilage. It consists of a series of cartilages called the *thyroid*, which is the prominent part seen in the middle line of the neck below the chin; the *cricoid*, which is a complete ring of cartilage just below the thyroid, and the *epiglottis*, which is above the back of the tongue. It has also three pairs of small cartilages more or less embedded in its soft tissues, which are lined by mucous membrane and surrounded by the muscles of the larynx. In the interior of the larynx the mucous membrane on each side is thrown into transverse folds that constitute the *vocal cords*, the upper folds being the *false vocal cords* and the lower the *true vocal cords*. By the approximation or separation of the true vocal cords the changes in the pitch of the voice are produced. The space between the true vocal cords is called the *glottis*, which is the opening of the larynx into the windpipe. The glottis is slit-like in shape during expiration, and large and triangular during inspiration. This opening is guarded on the top by the thin piece of cartilage, the epiglottis, mentioned above. This is a spoon-like lid, which open

when we breathe, but by a wonderful mechanism shuts when we swallow, and so lets the food glide over it into the *œsophagus* or food-pipe, and then into the stomach.

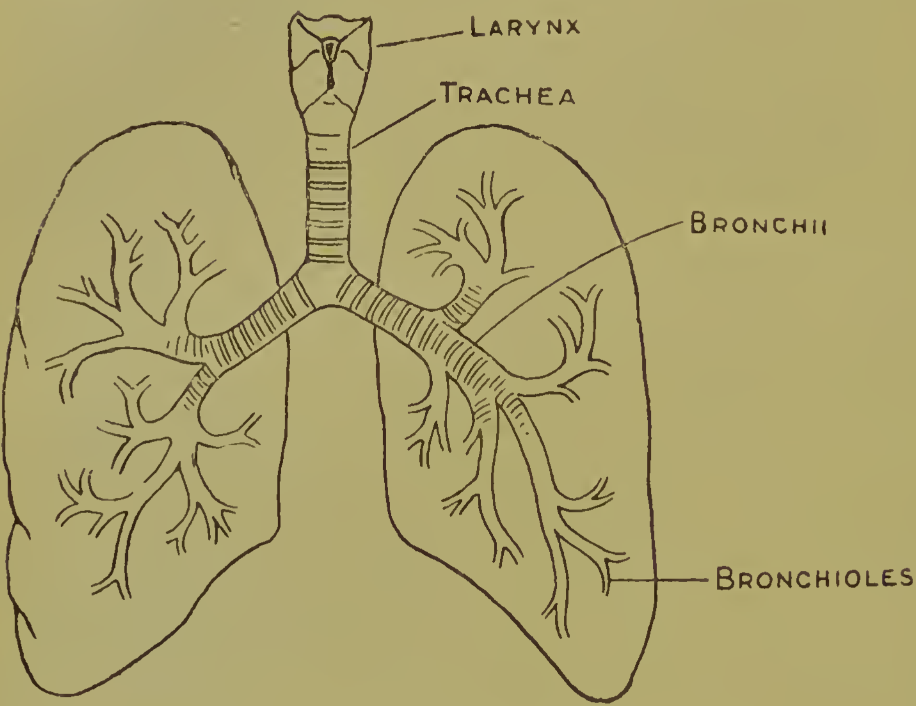

FIG. 20*a*.—Bronchi and lungs.

The position of the larynx in the neck is marked by a prominence in the middle line, below the chin, which is popularly known as "Adam's apple.

The trachea or windpipe and bronchi.—Below the larynx is the trachea or windpipe. This is an elastic tube, strengthened by C-shaped rings of cartilage embedded in softer tissues; the incomplete part of the rings are behind. The food-pipe is attached to, and placed behind, the trachea, and runs almost parallel with it. Shortly after entering the cavity of the chest, the trachea divides into two smaller tubes, called the right and left *bronchi*, which still further sub-divide and pass into the substance of the lungs, like the branches of a tree. At length, these *bronchial tubes* end in clusters of extremely small and fine *air-cells*. The stiff cartilaginous rings of the trachea and bronchi disappear gradually as we approach the smallest bronchial tubes. This arrangement allows the larger bronchial tubes to be constantly open, whilst the smaller, being elastic and containing muscular fibres, can vary their diameter. The smallest divisions of the bronchial tubes are called *bronchioles*.

The lungs.—The lungs are situated in the chest. They are the organs of respiration in which the impure venous blood is oxidised by the air drawn through the windpipe and bronchi into the air-cells. The right lung has three, and the left lung two *lobes*. At the root of each lung a bronchus and its artery, and the pulmonary artery and nerves enter, and the pulmonary and bronchial veins, and lymphatic vessels, leave. The lung itself consists of minute air-cells held in place by connective tissue. The average weight of the adult right lung is 22, and the left 20 ounces. The ramifications of the bronchial tubes and the air-sacs are lined with mucous membrane, which is very delicate and sensitive to the presence of anything except air. If the inspired air contains many particles of dust, these latter excite coughing, and by this means we get rid of the offending bodies. Along the lining of

all parts of the air-passages as far as the air-cells, are minute filaments of protoplasm called *cilia*, which are attached to epithelial cells and in constant motion, like an

FIG. 21.—Air-cells.

field of wheat stirred by a gentle breeze. These cilia serve to fan the air in the lungs, and to produce an outward current, which is useful in catching dust and fine particles swept inward with the breath.

The air-sacs which we have mentioned form the true substance of the lungs and give these organs their sponge-like character. Their walls are very thin, delicate and elastic, and contain a large number of minute blood vessels called capillaries. The air-sacs are so hollowed out that a single wall separates two adjoining cells. The air taken into the lungs enters them, and, from the thinness of their wall, comes almost into contact with the blood vessels, there being only a very thin film of membrane between them. A number of the waste or effete materials not required by the blood are thrown off through this thin membrane ; and, on the other hand, the blood abstracts from the air that which it wants, namely, oxygen. The oxygen so taken up by the blood is conveyed through the left side of the heart to the different parts of the body. Here it loses some of its oxygen, the tissues taking it as part of their food with avidity. But the tissues, in removing the oxygen from the blood, give to it in return their waste matters and harmful products, some of which are carried back to the lungs, and are largely given out to the air in the air-sacs, to be exhaled. It is by this natural contrivance that the blood is changed from being dark red and impure, to bright red and pure. It is only in this bright condition that it is fit to nourish the tissues of the body. In the lungs about 8 pints of blood comes into contact with the air of the air-sacs every minute.

The pleuræ.—The lungs are surrounded and enclosed by a fine delicate membrane which forms a double sac for each lung, the two layers of the sac being called the *pleuræ*. The wall of each sac is divided into two parts, one part, the *visceral pleura*, covering the lungs, the other part, the *parietal pleura*, lining the walls of the thorax. The cavities of the pleural sacs are only potential cavities, and they contain just sufficient fluid to prevent friction between the visceral and parietal pleuræ during the movements of the lungs and the thorax in breathing, but if either the parietal or visceral pleura is perforated and air is admitted, the lung collapses and the pleural cavity becomes full of air. When the pleura becomes inflamed (pleurisy), fluid often collects in the pleural cavity (pleuritic effusion).

Thorax or chest walls.—The cavity of the thorax or chest contains the heart and the large blood vessels springing from and opening into it, the lungs, the trachea, the bronchial tubes or air-pipes and the gullet or food-pipe.

By breathing, we cause the air to enter and leave the chest. The air is conveyed into and from the lungs, through the windpipe. Each respiration consists of two acts—*inspiration*, or taking air into the chest ; and *expiration*, or expelling it.

Inspiration.—When we draw in a full breath, we unconsciously straighten the spine and fix the head and shoulders, so that the muscles that expand the chest may act to the greatest advantage. At the same time, the *diaphragm** descends and presses the walls of the *abdomen*† outwards. By these means the size of the chest is increased and the elastic lungs expand to occupy the extra space; while the air rushes in along the windpipe and bronchial tubes, and reaches the air-sacs.

Expiration.—If we expel the air from the chest, the operation is reversed: we draw in the abdominal walls, and the diaphragm ascends; all together lessening the size of the chest cavity and sending the air from the lungs.

At each breath an adult inspires 25 or 30 cubic inches of air, but a much larger quantity may be inhaled.

Mechanism of respiration.—The blood in the lungs is constantly absorbing O and giving up CO_2 in exchange. To effect this the air in the air-cells of the lungs has to be constantly renewed. The mechanism of respiration teaches us the method by which this is carried out. The cavity of the chest is a closed air-tight chamber connected with the external air by the windpipe. The pressure of the air in the lungs keeps the lungs stretched and in contact with the chest walls. The contraction of the diaphragm causes the lungs to be pulled down and the cavity of the chest to be enlarged. When the diaphragm relaxes the size of the chest is lessened. The up and down movements of the diaphragm are the chief movements of ordinary breathing. The chest is also enlarged by the ribs being raised by certain of the muscles between the ribs (the intercostal muscles). One set of these contract and pull up the ribs which are fastened behind to the spinal column, and (those of the upper seven ribs) to the breast-plate in front. When the ribs are raised they push the breast-plate out or forwards in front and then the chest is enlarged all round. This latter enlargement occurs at the same time that the diaphragm contracts, so that the thorax is enlarged on all sides. A certain quantity of air then rushes into the lungs—these two actions represent *inspiration*.

Immediately following inspiration the diaphragm relaxes and ascends, and at the same time another set of intercostal muscles begin to pull the ribs and breast-plate down. These combined movements, together with the natural elastic recoil of the lungs, diminish the cavity of the chest, and consequently the same quantity of air is driven out of the chest that entered during inspiration. This is *expiration*. The lungs are highly elastic, expand with inspiration and recoil in expiration. Between inspiration and expiration there is a short pause.

The inspiratory part of ordinary quiet breathing is performed mainly by the diaphragm, and the expiratory part by the elastic recoil of the chest walls and lung tissue. A healthy man when at rest breathes about 15 to 18 times a minute.

* The broad muscular partition between the thoracic and the abdominal cavities.
† The cavity that contains the organs of digestion.

The actual quantity of air drawn into the lungs at each inspiration varies according to constitution, built of chest, and other circumstances. In an adult it is about 30 cubic inches, and it may be said that in an ordinary inspiration without any effort an adult inspires about a pint of air; by practice, however, as much as $9\frac{1}{4}$ pints of air have been inhaled.

Capacity of the lungs.—The full capacity of the lungs of an adult man of 5 feet 8 inches in height is about 330 cubic inches. At each ordinary inspiration about 30 cubic inches of air enter the lungs. This is called *tidal air*. After each ordinary respiration about 200 cubic inches of air remain in the lungs—this is termed *stationary air*. By a deep expiration about 100 more cubic inches can be expelled—this is called *supplemental air*. The remaining 100 cubic inches is called *residual air*—this cannot be expelled. By taking a deep inspiration 100 cubic inches extra can be inspired (making the full capacity to 330 cubic inches); this is called *complemental air*.

If we take a deep inspiration and then forcibly exhale all the air we can expel from the lungs, this amount, which is called the *breathing capacity* or *vital capacity* of the lungs, will bear a close correspondence to the stature. For a man of 5 feet 8 inches in height it will be about 230 cubic inches or about a gallon, and for each inch of height between 5 feet 8 inches and 6 feet there will be an increase of 8 cubic inches. As just stated another 100 cubic inches can be forced into the lungs by an extra effort, and is available for emergencies, or for purposes of training, as in singing, climbing, etc. This is of great importance, since, if the capacity of the lungs only equalled our momentary wants, the least obstruction would be dangerous to life.

It is by reason of the presence of the large volume of stationary air that we are enabled to hold our breath for a time without fatal consequences. It is to the presence of this that diving is possible, and by the existence of the residual and complemental air, which is being constantly renewed, the action of the air in the purification of the blood is rendered continuous. In the act of inspiration the air is not drawn into the ultimate divisions of the lungs, the air-cells, it reaches only the smaller bronchial tubes, whence it passes to the air-cells by gaseous diffusion.

Effects of Indian climate on respiration in Europeans.—As regards the European in India the following has been shown. The capacity of the chest for air is greater in India than in Europe, the increase amounting to 7 to 8 per cent. This is due to the fact that the lungs contain less blood and hence more room for air. The frequency of the respiration is decreased, and the respiratory act is as a whole lessened. This is due to the fact that although the chest capacity is greater, yet the diminished respirations more than counterbalance it, and moreover, heated air contains less oxygen per cubic foot, which further reduces the total consumption. The elimination

of carbonic acid gas is decreased owing to the fact that the amount thrown off bears a ratio to the quantity of air inspired.

Change of venous to arterial blood.—This change occurs as the blood flows through the capillaries of the air-cells. Through the delicate walls of these cells gases readily diffuse. The venous blood from the right side of the heart is heavily charged with carbonic acid gas. The pure blood contained in the left side of the heart is rich in oxygen. An interchange of gases therefore takes place, the oxygen gas passes from the inspired air into the capillaries and is taken up by the hæmoglobin of the red cells. The carbonic acid gas passes from the blood with the air contained in the air-cells and is given out in the expired air.

In 100 volumes of venous blood there are 10 volumes of oxygen and 46 of carbonic acid gas; in purified arteiial blood there are 20 volumes of oxygen and 39 volumes of carbonic acid gas.

It will be here convenient to make some remarks regarding the organs concerned in the circulation of the blood, and their structure, and to give a description of the blood and the process of coagulation.

Chief organs of the circulation.—The chief organs of the circulation are the *heart* and *blood vessels*, the latter consisting of the *arteries*, *capillaries* and *veins*.

The heart.—The *heart* is the great centre of the circulation. It acts as a pump and continues working from the dawn of life to death. It is throughout this time perpetually driving blood into the large arteries connected with it.

The heart is the hollow muscular organ which pumps blood throughout the body. It is placed in the middle line and slightly to the left of the thorax just behind the sternum or breast-plate, and between the lungs. Its base is directed upwards and to the right, its apex pointing downwards and to the left. In the adult it is about the size of the closed fist.

The "beat of the heart" may be felt on the left side of the chest about an inch below and an inch inside the left nipple. This beat is due to the apex of the heart striking the chest walls between the 5th and 6th ribs.

A muscular wall or partition extending from apex to base divides the heart into right and left sides. The right side contains impure venous blood, the left side pure arterial blood. These two halves are sub-divided into upper and lower halves by another muscular wall. The heart therefore contains four chambers. The upper chambers are called the *auricles* and the lower the *ventricles*—there are therefore a right auricle and ventricle, and a left auricle and ventricle.

The passages between the auricles and ventricles are furnished with valves which can close the communication. These valves open in one way only, and allow the blood to flow in that direction, and prevent its flowing in any other way. They are formed of thin flaps of tough fibrous membrane which hang from the edges of the passage into the ventricles. The valves between the right auricle and ventricle has three flaps and is called the *tricuspid valve*, that between the left auricle and ventricle has two flaps and is called the *bicuspid valve*; as this latter valve is considered to resemble a bishop's mitre it is also called the *mitral valve*.

The valves allow the blood to pass from the auricles to the ventricles quite freely. As soon as the blood attempts to return to the auricles it gets behind the flaps of the valves and forces them into apposition and so blocks up the opening.

The edges and corners of the flaps are attached to the ventricles by fibrous cords which are called the *chordæ tendinæ*. These cords are only just long enough to allow the flaps to come together, and no matter how hard the blood pushes against the valves they cannot go back any further as the threads are inelastic and do not yield to the pressure—the more the blood is forced against the valves the tighter these cords become, and the closer the contact of the valves with one another.

Both the auricles contract together and at the same time the ventricles relax; then the ventricles contract, and the auricles relax; and this goes on.

The Pericardium.—The pericardium is a membranous sac enveloping the heart. It is conical in shape, has its base attached to the diaphragm, and its apex surrounding the great blood vessels as they leave the heart. The pericardium consists of two layers, an outer, which is fibrous, and an inner, which is smooth and is reflected from the root of the large blood vessels on to the external surface of the heart. It secretes a pale yellow fluid, the *pericardial fluid*, whose function is to decrease the amount of friction during the beating of the heart.

Large blood vessels connected with the heart.—The chief blood vessels connected with the heart are—the *aorta*, *pulmonary artery*, *venæ cavæ* (superior and inferior) and the *pulmonary veins*.

The *aorta*, which arises from the left ventricle, is the largest artery of the body and is about the size of the thumb. Its opening is guarded by a valve like that at the entrance of the pulmonary artery. This valve allows the blood to flow from the left ventricle into the artery, but prevents it returning again to the left ventricle. The aorta conveys the purified blood charged with oxygen to the distributing arteries which carry it throughout the body.

The *superior vena cava* and *inferior vena cava* open into the upper and lower part of the right auricle, respectively. The entrance of the inferior vena cava into the auricle is guarded by a valve, called the *Eustachian* valve, which allows the blood to flow from the vein into the auricle, but prevents it from flowing back into the vein when the auricle contracts.

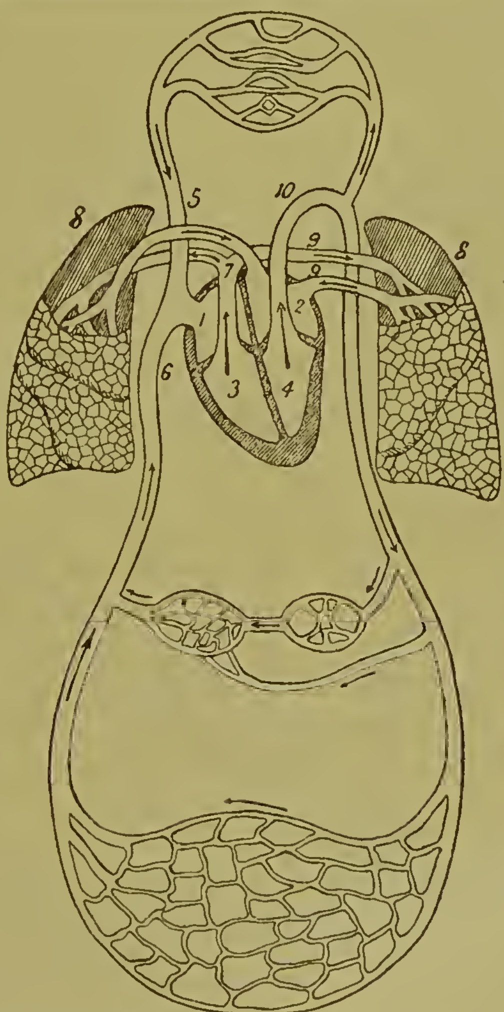

FIG. 22.—Diagram illustrating the circulation.
1, Right auricle; 2, left auricle; 3, right ventricle; 4, left ventricle; 5, vena cava superior 6, vena cava inferior; 7, pulmonary arteries; 8, lungs; 9, pulmonary veins; 10, aorta.

The superior vena cava brings the impure venous blood from the head, neck, and upper extremities, and the inferior vena cava brings the blood from the lower extremities and lower parts of the body.

The *pulmonary artery* arises from the right ventricle, its entrance being guarded by a valve. This valve is formed of three little half-moon-shaped pockets, hence the name *semilunar valve*. The mouths and openings of these pockets are turned towards the artery. When the blood is passing from the ventricle, the valves allow it to pass without resistance. As soon as the blood attempts to return from the artery to the ventricle, it fills the three pockets, their edges are forced together and the opening is completely closed.

The pulmonary artery shortly after leaving the right ventricle divides into two branches, one going to each lung. This artery carries the dark, purple, impure venous blood from the heart to the lungs. In the lungs this blood is purified and sent out again laden with oxygen which the blood has taken up from the air-cells. This purified blood which is now of a bright scarlet colour, is brought from the lungs to the heart by *four pulmonary veins* (two from each lung) which open into the left auricle.

In a healthy man at rest the heart beats about 72 times a minute, and at each beat a certain amount of blood is thrown into the arteries.

Circulation of the blood.—We may deal with the circulation of the blood under four headings:—

(1) The *greater* or *systemic circulation*, or the course of the blood through the body;

(2) The *lesser* or *pulmonary circulation*, or the course of the blood through the lungs;

(3) The *portal circulation*, which is simply a branch of the greater circulation and deals with the circulation of the blood through the stomach, spleen, pancreas and liver; and

(4) The *coronary circulation*, or course of the blood through the muscles of the heart itself.

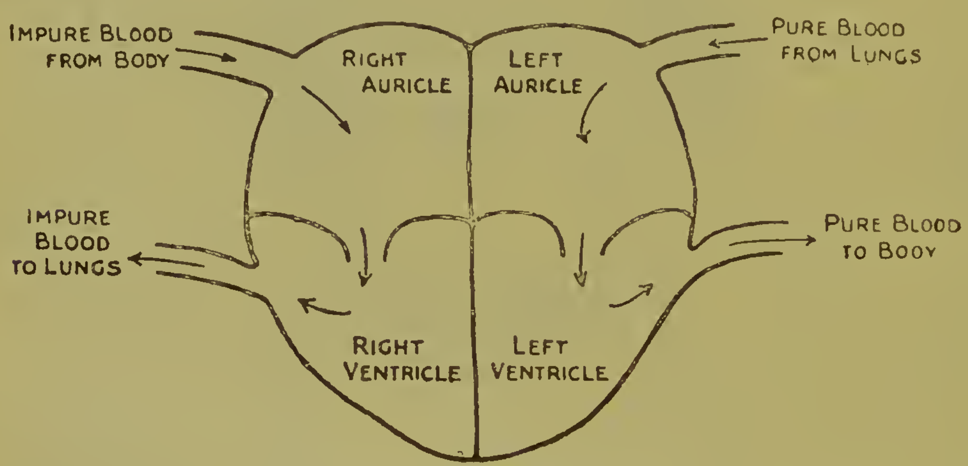

Fig. 23.—Diagram of Heart.

The greater circulation.—From the left auricle the blood is forced past one of the valves opening into the left ventricle (mitral valve); thence it is driven through the semilunar valves into the great aorta, which is the main trunk of the arterial system of vessels. Passing through the arteries, capillaries and veins it returns through two large veins, called the venæ cavæ (ascending and descending),

gathers again in the right auricle and so completes the round of the body. Both the greater and the lesser circulations are going on constantly; as the auricles contract the ventricles expand simultaneously, and *vice versâ* (Fig. 23.)

In the capillaries the flow is very slow, giving time for the nourishing fluid with its oxygen to ooze through their walls into the tissues. This stage in the greater circulation is that which is intimately connected with nutrition. At the same time the waste products from the tissues are taken up by the blood, and completely change the quality and appearance of the blood which has now been deprived of oxygen and much of its nutritive material.

The lesser circulation.—The dark blood from the veins collects in the right auricle, and going through one of the valves (tricuspid) on the right side of the heart, empties into the right ventricle. Thence it is driven past the semilunar valves, through the pulmonary artery, to the lungs. After circulating through the fine capillaries of the air-cells, it is returned, bright and red, through the four pulmonary veins to the left side of the heart (left auricle).

The coronary circulation.—This is the shortest course the blood can take from the left ventricle to returning to that chamber. The arteries, capillaries, and veins concerned in this circulation, carry the blood that nourishes the heart itself. The two main arteries of the heart are called the *coronary arteries.* These leave the aorta just behind the semilunar valves, and split up into small branches ending in capillaries, and these in veins.

Portal circulation.—The blood from the stomach, intestines, spleen and pancreas, is first collected up into a single vascular tube called the *portal vein ;* this passes into the liver, and, after branching and dividing in its substance, breaks up into minute capillaries, which finally end in the *hepatic veins* which pass from the liver into the inferior vena cava near its entrance into the right auricle.

The blood vessels and their structure.—The blood vessels of the body consist of *arteries, veins,* and *capillaries.* These are all patent tubes in which the blood continually flows, but they differ from each other in structure.

The arteries.—The arteries extend from the heart throughout the body and repeatedly split up into vessels of smaller size until finally these vessels are too fine to be seen by the human eye, and end in capillaries. The heart is constantly pumping blood into the arteries, whence it passes into the capillaries.

Structure of arteries.—A typical middle-sized artery is composed of three coats—an *outer* which consists largely of fibrous tissue, a *middle* which consists of muscular and elastic tissue, and an *inner*, which consists of elastic tissue and a fine membrane of epithelial tissue composed of flat cells united together by their edges. The larger arteries have more elastic tissue and the middle ones more muscular tissue ; the former are more elastic, the latter more contractile (Fig. 24*a*). The main arteries are deeply placed, but the smaller branches go to all parts of the body.

As a rule, arteries have bright red blood and veins dark purple blood. There is an exception to this in that the pulmonary artery carries impure venous blood and the pulmonary veins pure bright scarlet blood.

The pulse.—With each beat of the left ventricle a certain amount of blood is thrown into the aorta. The aorta is, however, already full of blood when this additional quantity is projected into it. The blood having been forced into the aorta cannot return to the left ventricle, because of the semilunar valve closing the opening. To accommodate this additional volume of blood the elastic aorta expands, and having been considerably dilated, it again, by virtue of its elasticity, returns to its previous size, and in doing so forces the blood onwards into the vessels near it (which also expand to receive it) and then relaxes, and so on all the arteries expand to receive the blood and recoil afterwards. It is this alternate swelling and recoil of the arteries that is felt when the finger is placed over an artery, and is called *the pulse.* If the finger is placed on the outer side of the front of the wrist, on the temple, or behind the inner side of the ankle, we feel the arteries in these situations beating.

The blood flows through the main arteries at the rate of 12 inches a second, but this speed is lessened as the arteries get smaller and smaller, until the blood, on reaching the capillaries, moves very slowly. The course through the capillaries is very short, seldom more than half an inch or so, and then when the blood leaves the capillaries the speed of flow again gradually increases, so that the whole course of the blood through the body occupies about 30 seconds. If any artery is cut, the blood gushes from it in jerks which correspond with the beating of the pulse. When we wish to stop the bleeding from an artery we bind up the artery on the side of the cut nearest the heart because the blood comes from the heart along the artery. If a vein is cut, the blood flows from it continuously and without jerks. To stop bleeding from a vein we bind up the vein on the side of the cut furthest from the heart, because the blood is coming from the capillaries towards the heart along the vein.

Structure of the capillaries.—The capillaries are extremely fine vessels about $\frac{1}{3000}$dth of an inch wide, which intervene between the smallest arteries and commencement of the veins. The walls of the capillaries are very delicate, being made up of a single layer of flat cells joined edge to edge by a cementing material to form a tube; these walls are permeable to the white blood cells, and permit of interchange of nutritive material from the blood to the tissue, and of waste material from the tissues to the blood. It is in this way that the tissues get nourished by the blood. At the same time the waste products of the worn out

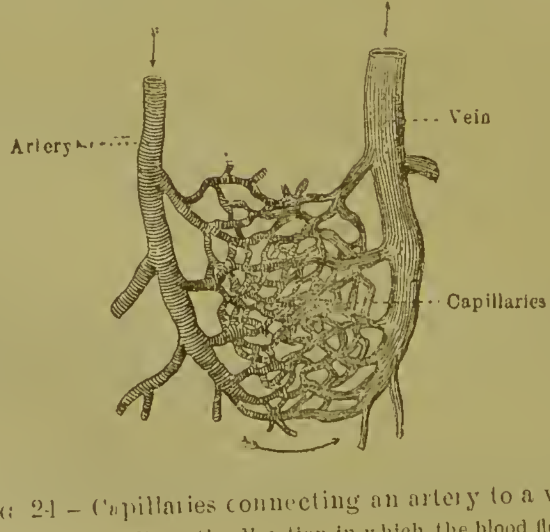

FIG. 24 – Capillaries connecting an artery to a vein.
(The arrows indicate the direction in which the blood flows.)

tissues are picked up, removed from the tissues, and find their way to the blood

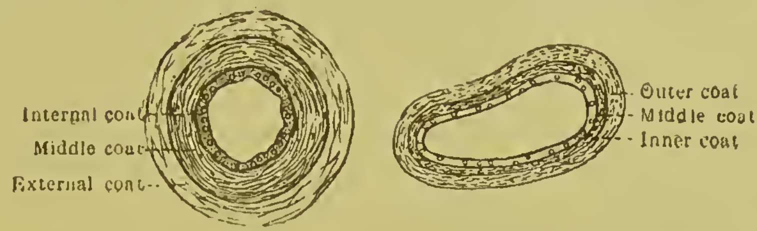

FIG. 24a.—Transverse section of an artery and a vein of corresponding size (magnified). After WARWICK and TURNSTALL.

through the walls of the capillaries. These waste products are afterwards thrown off from the body by special organs for this purpose, *viz.*, the kidneys, lungs and skin.

From the capillaries the blood is gathered up by the veins which get larger as they get nearer the heart, and are *en route* joined by other veins.

Structure of the veins.—The veins are thin walled tubes which collapse when empty. In most of the veins there are found valves, which are usually placed in pairs and look towards the heart. These valves are more numerous in the veins of the lower extremity and in the veins of muscular parts. Some veins, as the superior and inferior vena cava, pulmonary veins, and portal vein, have no valves. The valves serve to prevent the backward flow of blood into the capillaries during muscular contraction. The little knots seen in the arm of a muscular man when the fist is tightly closed, represent the position of the valves of the veins. If the finger is pressed on the large superficial veins at the bend of the elbow, these knots appear in the forearm below the point of pressure because the blood is prevented from flowing towards the heart and the little pouches prevent it flowing backwards. If the finger is taken off the vein the knots disappear, because the blood is now allowed to flow towards the heart without interference.

A typical vein has three coats—an *outer*, consisting of elastic tissue and muscular fibres, a *middle*, consisting of muscular and fibrous tissues, but much thinner than the middle coat of an artery, and an *inner* of similar structure to the inner coat of an artery.

The veins are more numerous than the arteries and are arranged in two main sets—a *superficial* set just beneath the skin, and a *deep* set which accompanies the arteries. All the blood coming from the head, neck, upper extremities and the thorax is finally collected into one large vein called the *superior vena cava.*

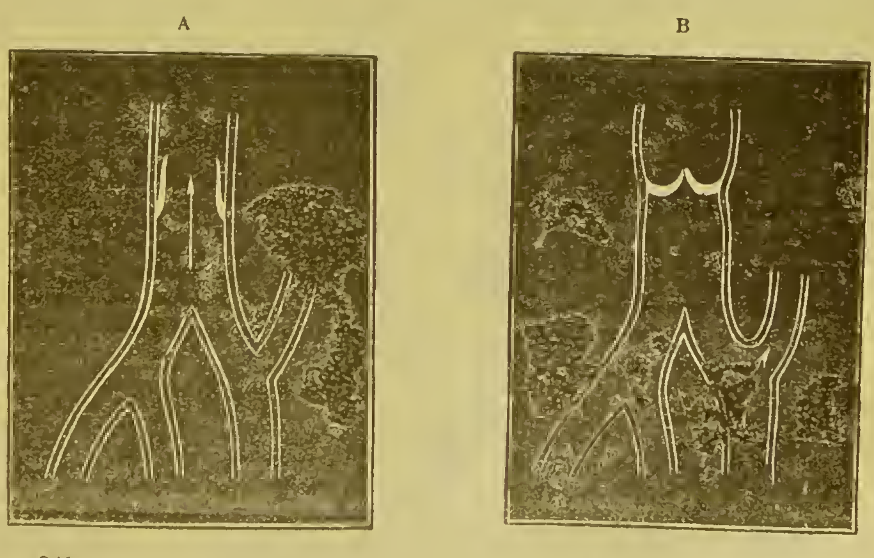

FIG. 24b.—A, vein with valves open; B, with valves closed; the arrow in B indicates stream of blood passing off by a lateral channel (DALTON).

Functions of the circulation.—The offices of the systemic circulation is to convey oxygen gas (in the hæmoglobin of red cells), and nutrient matter (in the plasma) to the different organs and tissues; to collect, by means of the capillaries, substances which result from wear and tear (and which are of no further use to the body) and convey them to the lungs and other organs of excretion. The function of the *pulmonary* circulation is to aerate the blood whereby the impure venous blood becomes changed into oxygenated pure blood. The function of the portal circulation is the elaboration of nutriment.

How the blood is purified.—The blood is purified in three ways:—(1) By passing through the blood vessels of the lungs, where it gets rid of carbonic acid gas (the result of the oxidation of carbonaceous or heat-producing substances in the tissues and organs of the body), and excess of water in the form of vapour; (2) by passing through the vessels surrounding the sweat glands under the surface of the skin, where it gets rid of excess of water (in the form of perspiration), a small quantity of carbonic acid gas, and a little urea (the result of destruction of nitrogenous or tissue-forming substances); and (3) by passing through the blood vessels of the kidneys where it gives up excess of water with a large proportion of urea and a little uric acid, both these latter being held in solution in the urine.

Composition of the blood.—The blood is the fluid that circulates through the heart, arteries, veins and capillaries, and supplies nutritive material to all parts of the body. The blood itself consists of a colourless *plasma* in which are suspended red and white cells or corpuscles. Physiologically, we look upon the blood as a living tissue. When exposed to air the blood coagulates, forming a red clot, from which a yellowish fluid, the serum of the blood, oozes. Healthy blood consists of about 79 per cent. of water and 21 per cent. of solids.

The blood when first drawn from the body is a red somewhat sticky fluid which has a much higher specific gravity than water, and is apparently homogeneous. If a small drop is allowed to fall on a microscope slide, and a cover glass is placed over it, and then examined under a microscope, it is found that the blood consists of an almost colourless fluid, called the *liquor sanguinis* or *plasma*, and an enormous number of small bodies, called *blood-corpuscles*, of which there are two kinds, *red* and *white*.

Red blood cells.—The red cells are about $\frac{1}{3200}$dth of an inch in diameter and $\frac{1}{12000}$dth of an inch in thickness. It would take about ten millions of them to just

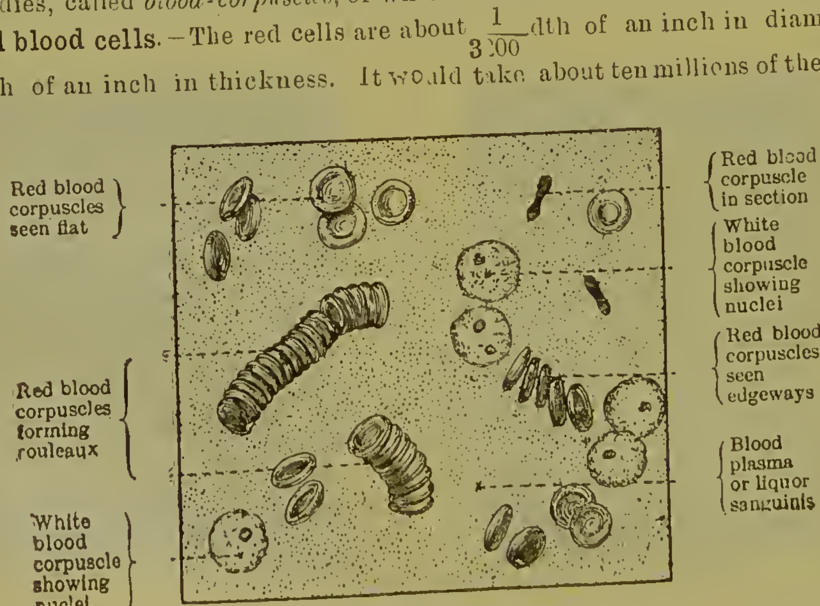

Fig. 25.—The blood (magnified).

cover a square inch of surface in a single layer. The red cells are biconcave circular discs; they are highly elastic, and can alter their shape when running in the smaller blood vessels (Fig. 25). There are about 650 red corpuscles to each white corpuscle. Outside the body the red cells have a tendency to run together and form little groups like piles of coin (*rouleaux*). The colour of the red cells is due to the *hæmoglobin* in them. This is comparable with *chlorophyll*, which is the green colouring matter of vegetable cells. Hæmoglobin is composed of a proteid* or organic nitrogenous body, which on decomposition yields a pigment containing iron, called *hæmatin*, and a proteid body, called *globin*. The hæmoglobin of the red cells is most important, as it is the oxygen-carrying substance of the blood, the oxygen being loosely combined with it so that it may be readily abstracted by the tissues and cells of the body. The red cells take up oxygen in the lungs and carry it to the various tissues and cells. In the working of the tissues and cells of the body, oxygen is constantly required. The blood in the arteries is charged with oxygen and it is the combination of a large amount of oxygen with hæmoglobin that gives arterial blood its bright scarlet colour. The blood in the veins contains less oxygen because it has parted with much of it to the tissues. The colour of the blood in the veins is dark purple. This venous blood is not suited to the nutrition of the tissues.

In the adult man the chief seat of the formation of red corpuscles is in the red marrow of bones. In the connective tissue of red marrow, we find certain large pale cells which deposit hæmoglobin within their protoplasm, and this becomes collected into small masses which are formed into red cells and discharged. In addition to this there are within the marrow a number of small amœbæ-like cells tinted with hæmoglobin, which actively divide and become red corpuscles. It is possible that the spleen can also form red cells; the main evidence that it may do so being that when the spleen is removed in animals, the regeneration of red cells of the blood is much slower than in normal animals.

Fate of red cells.—There is much evidence to show that the bile pigments formed by the cells of the liver are derived from hæmoglobin, and therefore as bile pigment is eliminated constantly, there must be a constant destruction of red cells. Anything which tends to produce destruction of red cells (and this is a condition resulting from the toxins of several infectious diseases) causes a proportionate increase in the excretion of bile pigments.

White blood cells.—The white corpuscles, white cells, or leucocytes, are slightly larger than the red; they are not flat or disc-like; they exhibit movements similar to those of the amœbæ or lowest forms of animal life; they are constantly changing their shape, being now spherical, a few seconds later pear-shaped, and so on (Fig. 25*b*). We do not know all the functions of the white blood cells, but one we know is that they are important in protecting us from the effects of extraneous matter reaching the blood, such as disease microbes, when these are not in overwhelming numbers.

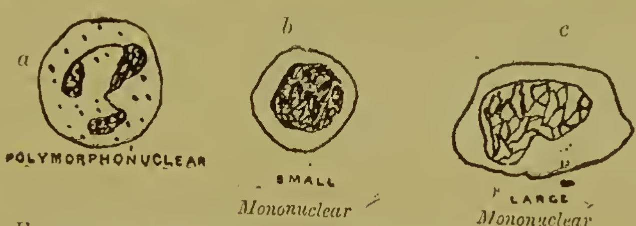

FIG. 25*a*—Various forms of white blood cells:
(*a*) Polymorphonuclear cell, (*b*) Small white cell.
(*c*) Large white cell (after STEPHENS and CHRISTOPHERS).

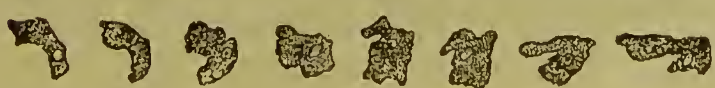

FIG. 25*b*.—Human white blood-corpuscle, showing its successive changes of outline within ten minutes when kept moist on a warm stage (SCHOFIELD).

* *Proteid* is a general term applied to the nitrogenous or albuminous part of vegetable and animal substances. There are various proteids, these are specially referred to under FOODS.

There are various forms of white cells which are classified according to their general shape, the amount of their protoplasm, or the shape of the nuclei, or again the structure of the protoplasm and its contents. The chief kinds of white cells are—*small leucocytes*, which are small cells with a large spherical nucleus; *large mononuclear leucoctyes*, which are two or three times the size of red corpuscles, with an oval nucleus; *transition cells* similar to the last mentioned; *polymorphonuclear leucocytes*, which are similar than the last two, with nuclei which are sub-divided. There are a few other forms which we need not mention here. The small leucocytes are formed in lymphatic tissue scattered throughout the body, especially in lymphatic glands, and these gain access to the general blood stream through the lymphatic vessels. The large mononuclear, transitional and polymorphonuclear cells, arise in the bone marrow.

Fate of white corpuscles.—A large number of white cells are daily formed, and there must consequently be a daily destruction of a corresponding proportion. A large number are destroyed in the blood itself and in the spleen.

The *liquor sanguinis* is not a simple fluid. When the corpuscles are separated from the blood, it is seen that the latter in bulk is a straw-coloured fluid; it is almost colourless when seen as a thin film under the microscope. If allowed to stand it forms a clear jelly-like mass. The blood contains also an agent called *fibrin ferment* which causes a material in the plasma (known as *fibrino-plastin*), and another body in the white cells, to combine and form *fibrin*; coagulation of the blood is brought about by the formation of fibrin.

Functions of the blood.—The blood carries nourishment to all the tissues and cells of the body to build them up, or to repair the waste that has occurred in them from work, wear and tear. It absorbs nourishment from the food products and conveys it to the tissues. It provides the body with water. It absorbs large quantities of oxygen in the lungs and carries it to all parts of the body. This is effected by the red cells. Oxygen is necessary for the working of all tissues and cells. In this working the oxygen is consumed or slowly burned up. This combustion produces heat and energy. In doing so waste products are formed which if allowed to remain in the body would be harmful. The tissues and cells are largely composed of C, O, H, and N, and in the process of combustion the C and O unite to form CO_2, the H and O combine to form H_2O. Another complex body called *urea* is formed during these processes of oxidation, which consists also of C, H, O ,and N, and has to be got rid of. The blood is also the means by which all the waste products are taken away from the body, carrying these to the excretory organs—kidneys, lungs, and skin. The constant oxidation going on in the body produces a large amount of heat; the blood acts like the hot water-pipes used for heating houses and distributes this heat uniformly throughout the body. The blood produces all the materials required for forming certain secretions or juices in digestion—from it the cells of the salivary glands secrete saliva, the glands of the stomach secrete gastric juice, the liver forms bile, and so on.

Composition of the air.—The air may be considered to consist of an ocean of mixed gases that surround the world. This ocean is about 50 miles deep. It is really much deeper, but beyond 50 miles from the earth, it becomes very much rarified. The lowest layer, or

that which we breathe, is much heavier than the layers near the top. The air owing to the force of gravity is much denser near the earth and gets attenuated layer by layer as we ascend. Air is invisible, and we are only made aware of its presence when it is in motion* or when we are moving against it.

Air is composed of a mechanical mixture of two gases,† one called *oxygen*, another *nitrogen*. Ordinary air always contains a few other agents, of which the chief are *carbonic acid gas*, *ammonia*, and aqueous or *watery vapour*, particles of mineral substances of dead and living organised matter. The solid particles of dust suspended in the air are seen when a beam of sunlight passes into a room ; such solid impurities in the air may include the germs of disease. Under the influence of good ventilation and abundance of light in houses these are diluted, removed, or to a large extent rendered harmless. With the exception of carbonic acid gas and aqueous vapour, the relative proportions of the other constituents remain tolerably constant throughout the globe. The carbonic acid gas and ammonia are in such small quantities as not to affect the qualities of the air for human respiration.

Carbonic acid gas.—Good fresh air contains 4 parts of carbonic acid gas in 10,000 parts or 0·4 parts in 1,000. Expired air contains about 4 parts in 100. If the air in occupied rooms reaches 1·5 parts per 1,000 it is associated with the production of headache, langour, sluggishness of body and mind ; and 5 parts per 1,000 for any length of time would be incompatible with life.

Neither the carbonic acid gas nor ammonia serves any useful purpose in the animal economy, but they are of immense use to plant life. The ammonia‡ of the air supplies plants with part of the nitrogen they require as food.

Carbonic acid gas is invisible and about $1\frac{1}{2}$ times heavier than air ; on account of its density it can be poured from one vessel to another. The carbonic acid is to the vegetable kingdom what oxygen is to the animal—a necessary food. Plants breathe just as animals do, only they reverse the process—they take in the carbon of

* Air in motion is called *wind.*

† All things in the world belong to one of three classes—solids, liquids or gases. *Solids* are bodies that have a fixed shape and possess a certain amount of hardness, such as a piece of wood or stone or metal. *Liquids* are agents that have no constant shape ; they take the form of the vessels that contain them. *Gases* are bodies that have no fixed shape, and always tend to increase in volume. All three classes are made up of minute invisible particles called *atoms*. In a gas every atom is trying to drive away the neighbouring atom.

There is another gas called *argon* in air to the extent of 1 per cent., but as this gas is negative and has the same diluting properties as nitrogen, it is not specially considered here.

‡ *Ammonia* is a gas composed of one atom of nitrogen and three atoms of hydrogen.

the carbon dioxide and set free the oxygen. When oxygen and carbon are united with one another to form carbonic acid gas, we are not able to utilise either of these elements. Plants, on the other hand, *are* able to split up the carbonic acid gas into its component elements. When the sun shines on the green colouring matter of leaves or chlorophyll, it causes this chlorophyll to pick out and retain the carbon of the carbonic acid gas of the air and sends back the oxygen for us to breathe; plants, therefore, help to purify the air; further, the carbon that the plants have taken in is so changed and combined with other bodies in the plants as to make it fit for us to take as food. At night most plants reverse the order of breathing; they take away the oxygen and give off carbonic acid gas, but, on the whole, they give out more oxygen than they take up from the air. The carbonic acid gas itself, being usually in comparatively small quantities in the air, is not poisonous. In inhabited houses, however, it is accompanied with a certain quantity of the noxious animal matters and foul organic gases given off by the lungs. When the carbonic acid gas is in excess, the animal matter is in excess also. Exact and scientific observations have proved that the amount of carbonic acid gas contained in an inhabited room corresponds with the amount of impure animal organic matter contained in that room. The amount of carbonic acid gas in the air is, therefore, taken as a measure of the purity of the atmosphere in rooms. Excess of it in air tells of excess of respiratory animal impurities.

Sources of carbonic acid gas in air.—The chief sources of carbonic acid gas in the air are :—

1. Subterranean sources and from the soil. The subterranean sources are considerably more than all the other sources put together. This source of carbonic acid gas is partly produced by the processes of combustion continuously going on in the more superficial parts of the earth's crust, and in part from the diffusion of pent-up gas in natural reservoirs, large and small, produced in past ages.

2. The respiration of man and animals.

3. Processes of combustion.

4. Fermentation.

5. The escape of carbonic acid gas from natural waters in which it is held in solution.

6. Decayed vegetable and other organic matters—specially emanating from the soil.

In general terms it may be said that the chief impurities of air are the products of respiration, combustion and decomposition generally, and ordinary dust which often carries disease germs. *Dust* may consist of particles of dried saliva, fæces, epithelum from the surface of the body, fibres from different clothes fabrics, particles of carbon, ordinary sand and clay particles, vegetable cells, wings of insects, etc., to all of which may be attached disease-germs. The number of bacteria in air depends on the extent of pollution of the air, moisture of surrounding surfaces, temperature and humidity of the air, and season of the year. The more dust in the air the greater the number of bacteria. On the tops of mountains there is little dust and few bacteria, in crowded rooms there is, as a rule, much dust and crowds of bacteria. Dust particles attract bacteria of the air of all kinds to their surface. Damp and moist surfaces also attract

bacteria from the air. More germs are present in houses in summer than in winter but there are fewer in the outside air in summer than in winter, as direct sunlight is a powerful germicide. The motes of a sunbeam passing through ordinary pure air, even away from habitations, shows that it contains floating particles of dust and débris associated with many of which are microbes. In inhabited places these particles are in vastly greater numbers and often have mixed with them disease-germs. The watery vapour from the lungs catches up the particles of dust and microbes, and suspends them to be breathed by us.

Oxygen and nitrogen.—One hundred parts of air contain about 79 parts of nitrogen and 21 of oxygen, or roughly four of the former to one of the latter. The oxygen is much the more important of the two ; it is the gas which supports life, the vital element of the atmosphere, and is a very active gas, which serves the purpose of keeping our blood pure. Oxygen combines with other bodies and burns them up. Without it we could not produce light or heat from any combustible substance, nor could life be supported. Inside our bodies oxygen combines with the materials of the food and burns, and thus maintains the natural heat of the body ; but the burning goes on so slowly that we do not feel the heat it produces: this is the chief way in which our bodies are kept warm. Oxygen is so active that if the air contained only this one gas, it would burn us up. If we put a lighted candle in pure oxygen, it burns very brightly and wastes away much more rapidly than if we put it in ordinary air. But if we deprive the air of its oxygen, and put a lighted candle into the remaining nitrogen, the candle goes out at once. A person breathing impure expired air over and over again often suffers from giddiness, headache, and faintness. In crowded assemblies in badly ventilated theatres, churches, etc., people often faint from this cause. If a man were shut up in an air-tight chamber measuring six feet every way, he would die in a little over an hour, chiefly because all the oxygen in it was used up. Nitrogen is a harmless gas : nothing will burn in it. Animals would die at once if they had only nitrogen to breathe. Oxygen alone is far too strong for us to breathe. The nitrogen is mixed with the oxygen to dilute it. Nature has provided a mixture of these two gases in such proportion to one another that the air can be breathed by man and animals ; lamps and fires can be kept alight in this mixture of gases.

In the human body then the oxygen sustains combustion and supports life by combining with and oxidising the tissues, and so producing heat; the nitrogen dilutes the oxygen which by itself would be too strong and act too rapidly on the substance with which it comes into contact; the carbonic acid gas is the result of the oxidation of the tissues. No change occurs in the nitrogen.

Ozone, which is an active modification of oxygen, though always present in the purest airs, is so readily reduced by the oxidisable organic matter in the ordinary air of towns and dwellings, that it is practically never present.

Some watery vapour is always contained in the air and a certain amount of it is beneficial, both for animals and plants; if in excess, as it is along our sea-coasts, and along the Eastern Frontier it makes the climate relaxing. If very small in amount it makes the air dry, thereby causing much evaporation from the skin.

Composition of the air we expire.—We now know what ordinary pure air contains. Let us contrast this with air given off from the lungs:—

	Inspired air. Volume per cent.	*Expired air.* Volume per cent.
Oxygen ...	21	16·5
Nitrogen ...	79	79
Carbonic acid gas	·04	4·5
Watery vapour	Variable	Saturated.
Organic matter	Absent	Present.

Air which has passed through the lungs contains from 16 to 17 per cent. of oxygen and 4 or 5 per cent. of carbonic acid gas. We see that the air in passing through the lungs loses 4 to 5 parts of oxygen and gains 4 to 5 parts of carbonic acid gas. The nitrogen of the air in passing through the lungs remains unchanged. It simply serves as a medium for the dilution of the O required. Ordinary air contains a small amount of watery vapour, that leaving the lungs is saturated with this vapour. Air leaving the lungs is about 98 F., no matter what the temperature of that entering it. Air leaving the lungs contains a certain small amount of decaying animal matter.

Watery vapour.—As just stated one of the things given off from the lungs is *watery vapour*. An adult, in 24 hours, gives off from 9 to 11 ounces of water from the lungs. In the cold weather we can see clouds of steam coming from the mouth. This visible vapour is water in a finely divided state. We can also prove that this watery vapour leaves the mouth by breathing on to the front of a looking-glass. By doing this we notice that the mirror is dimmed and becomes damp directly. The air we inhale contains a small and variable amount of water, but the air we exhale always contains as much water as it can hold in the state of vapour or steam. The expired air is, therefore, said to be *saturated* with watery vapour.

*Carbonic acid gas.**—We also breathe out carbonic acid gas, which is colourless; but we can readily prove that it is expired. Get a bottle containing some clear *lime water* and breathe into it through a glass tube. We notice that the clearness of the lime water soon disappears—it becomes milky. This change is effected by the carbonic acid gas uniting with the lime of the lime water, to form fine particles

* Carbonic acid gas is made up of oxygen and carbon. We have learnt something about oxygen already. If we burn a piece of wood closed in a case so that very little or no air reaches it, the wood turns black. This dark mass is called *charcoal* which is almost all *carbon*. When this carbon combines with abundance of oxygen, *carbonic acid gas* is formed.

of *chalk*. Or, breathe into a jar, and lower a lighted candle into it. We will find that the flame is instantly extinguished, showing the presence of carbonic acid gas. Ordinary air contains a little carbonic acid gas, expired air contains about 100 times as much. In this manner a man in twenty-four hours sends off from his lungs as much carbon as is contained in a piece of charcoal weighing 8 ounces. We are unable to see the carbon, because it has combined with oxygen to form carbonic acid gas, which is colourless. Fortunately the carbonic acid gas of respiration (and other impurities) is rapidly diffused and rendered weaker. Fresh air from rural districts is constantly rushing in and diluting the impure air of cities and towns, just as the pure air over the great oceans is driven to and mixes with the air covering the land.

Each person of a mixed community exhales 0·6 cubic foot of carbonic acid gas per hour, and this fact is made use of in ascertaining the amount of air required per head per hour. In calculating this amount we divide the amount of carbonic acid gas exhaled per hour by the limit of admissible impurity of carbonic acid gas stated in cubic feet (admissible impurity = 0·02 per cent. in one cubic foot). This gives us $\frac{0{\cdot}6}{{\cdot}0002} = 3{,}000$ cubic feet, and this is the amount of fresh air required per head per hour in a mixed gathering of people in order that the fixed standard of freshness be maintained. When the air in a room contains 0·7 of a cubic foot of carbonic acid gas to 1,000 cubic feet we may be able to recognise that the ventilation is not good by the senses; 0·9 cubic foot is distinctly perceptible. Sick people require 4,000 cubic feet of fresh air per hour, and this amount should be provided for in hospitals; the more the air of hospital wards approaches that of the outside air, the better for the patients. Sick people recover but slowly in small, dark, badly ventilated rooms; and when they are suffering from infectious disease in such rooms, all those in attendance on them run great risk of acquiring the disease from the density of the specific microbes in the air. The average man breathes about 18 times in a minute when at rest and expires about 25 to 30 cubic inches of air each time; that is, 330 cubic feet in 24 hours. As the expired air contains about 4·4 per cent. of carbonic acid gas, a man gives off $\frac{330 \times 4{\cdot}4}{100} = 14{\cdot}25$ cubic feet of carbonic acid gas in 24 hours, or 0·6 cubic foot in an hour. The animal matter contained in inhabited rooms becomes noticeable to the sense of smell when the carbonic acid gas reaches 0·8 volume per 1,000 volumes of air, and it becomes oppressive when it reaches 0·9. The injurious effects from breathing impure air in badly ventilated rooms is due to several factors, such as increased temperature and humidity, disagreeable smells, the poisonous organic animal matters exhaled, deficiency of oxygen and excess of carbonic acid gas—it is this combination that leads to headache, langour, and depression, often to nausea and even sickness and fainting. Neither the watery vapour, nor the carbonic acid, is poisonous, but they are in company with other bodies which are very poisonous. Some watery vapour is always contained in the air, and a

certain amount of it is benefical both for animals and plants. If in excess, as it is in Lower Bengal and most sea-coast towns in India, it makes the climate relaxing.* If very small in amount, it makes the air dry, thereby causing much evaporation from our bodies and from plants. Very dry air is injurious to plants.

Animal matter.—We also breathe out minute particles of animal matter, and several varieties of organic gases, which are all ready to decay and putrefy. It is this putrid animal matter that is so noxious in air that has once been breathed. Many years ago, when houses and jails in England were more densely crowded with people than they are now, outbreaks of "plague" and typhus fever arose. It was formerly believed that the chief cause of these outbreaks was the impurity of the air from the decomposing animal matter and organic gases exhaled from the lungs of human beings. We now know that these impurities of the air only acted as predisposing causes, the essential cause in plague being a specific bacillus, whilst in typhus it is probably an infective micro-organism yet to be discovered. Recently, this animal matter was isolated in a crystalline form by a chemist, and it was found that very small quantities of it were capable of killing dogs and rabbits. If you confine the expired air in a bottle for a time, the animal matter decomposes and gives out an offensive smell.

Although the carbonic acid of expired air diffuses pretty readily, the organic matter is less volatile, and hangs about in invisible clouds unless dissipated by local curreuts. Hence the composition of air in an occupied room is not uniform, even at the same level, though for practical purposes it may usually be assumed to be so. In a large room occupied by many persons both the local currents and the foci of pollution are numerous, so that the composition of the air is much more uniform than in a small room occupied by one person. The outlet should be at or near the highest point, since expired air, being warm and moist, is lighter than ordinary air, and ascends at first to the upper part of the room.

Recognition of foul air.—The foul animal particles and organic gases are themselves invisible, but we can recognise them by the sense of smell, and also by the effect they produce on us if they are present beyond a certain ratio. Particularly can we notice their presence if we come into a crowded room or tent after being in the fresh, open air. They cause the air to be close, stuffy, and disagreeable. The sense of smell ought to protect us from the evils connected with the breathing of foul air. As with most other things, people get accustomed to bad smells, and then the poisonous gases and putrid animal matter in the air do not *appear* to be so harmful as they were at first.

* Relaxing climates are such as produce a want of general vigour, and until one becomes acclimatised, cause the various functions of the animal economy to be carried on sluggishly.

A catastrophe occurred on board the Irish Steamer "Londonderry" on the stormy night of 2nd December 1848, when 200 steerage passengers were thrust below into their narrow cabin which measured 18 feet × 11 feet and 7 feet in height, and in which there was no ventilation. The hatches were battened down and covered with tarpaulins. In the morning 72 were found dead and several expiring.

This is an extreme case, but it helps to illustrate forcibly the danger arising from inhaling air deprived of its due proportion of oxygen and laden with animal effluvia *even when that air is exhaled by persons in perfect health.* Even where there is efficient removal of all animal and other organic refuse from the house, disease may arise from simple want of proper ventilation.

Short of producing actual death, the constant breathing of air rendered slightly impure by previous respiration, tends to undermine health. The blood is then not properly purified, and in this impure state is ready to receive the germs of disease at any time. It is this condition of the atmosphere of the rooms that begets the general langour of which people so frequently complain. If proper means are not adopted for getting rid of this foul air from bed-rooms, we wake up in the morning feeling heavy, unrefreshed, and disinclined for our day's work instead of being fresh, brisk, and active.

Defective ventilation and a stagnant air in a room may bring about a depraved condition of health, general debility, indigestion, bronchitis, pneumonia, a susceptibility to pulmonary tuberculosis or other lung troubles, and a predisposition to heatstroke.

Other ways in which air is rendered impure.—Besides the fouling of the air produced by human respiration, air may be rendered impure in several other ways:—

(1) *Burning of lamps and fires* renders the air impure. When an oil lamp or candle is burning, it gives off water, carbonic acid and some complex bodies which give the smell we notice. A lamp will not burn in the absence of oxygen. It uses some of the oxygen of the air we should get. One candle consumes as much oxygen as a child. One gas burner consumes the more oxygen and evolves more carbon dioxide than 6 or 8 candles. Hence when gas is employed to illuminate, not only should care be taken to secure the constant introduction of pure air, but also to provide for the escape from the apartment of the gases produced in the light through a tube or funnel. This tube might be conveyed to the chimney when there is one, and to the external air when there is not. Enough air should be supplied, then, for ourselves, the lamps, and any fires situated in inhabited rooms.

(2) When *animal or vegetable matter is decaying,* it gives off foul gases, which mix with the air and are inhaled by us. The sense of smell should enable us to detect these bad odours, and lead us to remove whatever created them. Men should not leave bits of stale meat, or the leavings of a meal, skins of vegetables and fruits, mango stones, or sugar-cane refuse in barrack-rooms or tents; they should be thrown into the dust-bin, or refuse-pit or place specially fixed to receive them.

(3) *Cooking in inhabited rooms* gives a sense of heaviness to the air breathed and takes away the appetite.

(4) *Clothes should never be washed in rooms;* this process causes the foul water to soil the room and its air, besides making it damp.

(5) *Dirty floors, dirty furniture and dirty walls* of barrack-rooms or tents give a peculiar unpleasant smell to the air. Dirty clothes, boots and socks, also give out offensive odours. All inhabited rooms and tents and their sidewalls and their contents should be kept clean. This is largely assisted by keeping the doors and windows open, which, in addition to letting in air, gives access to *light*, which *shows where the dirt is.* A dirty room in the hot weather is rapidly invaded by a plague of flies.

(6) *Badly constructed drains, and the absence of drains*, also add greatly to the impurities of the air in and near barracks. If ever we get a smell from a drain, it is poisonous gas or gases that produce it. This smell may be removed and prevented by flushing all drains, in and around the barracks, regularly with water. If the drains are clean, and yet these bad smells arise, the cause is due to pollution of the soil from decomposing and putrid animal and vegetable matter. Such smells cause many forms of sickness—especially certain infectious fevers, sore-throat, diphtheria, diarrhœa, etc.,—any one of which may prove fatal. But short of causing any serious disease, foul drains and putrid soil may bring on a feeling of undefined ill-health—just in the same way that a small quantity of arsenic may cause a certain amount of discomfort, yet a larger quantity will kill outright. Ground that is fouled by slops and house refuse is constantly giving out bad gases. In the soil, as in our lungs, the air is constantly being changed. Pure air enters the soil, but in leaving it carries away foul gases, which mix with the air we breathe. Further, if the ground is moist (as it often is around imperfectly drained houses), the gases are damp as well as foul. It is very necessary to have proper drains attached to each house, so that all waste and refuse fluids are at once conveyed to a distance from the dwelling.

(7) *Sick people give off foul gases* and other injurious bodies such as the germs of disease, which may be direct poisons. These foul gases are of a more harmful nature, and greater in quantity, than healthy people give off. Many diseases are due to the entrance of minute invisible vegetable germs into the body. Nature tries to throw off these germs either by the lungs or otherwise. If the germs of infective disease once find their way into the body, some descriptions of them may rapidly multiply. Such seeds or germs come away in great numbers from the lungs and bodies of persons suffering from small-pox and other diseases. The germs of small-pox are diffused through the air of the room occupied by the patient, and if we inhale them, and have not had small-pox before, or have not been properly vaccinated, they are likely to give us the disease. These remarks apply equally to such diseases as measles, mumps, chicken-pox, etc. Germs have been found in connection with most of the general infective diseases.*

(8) The air in and around graveyards is impure. Burial grounds should, therefore, be at a distance from barracks. The same may be said of the air near *brick-kilns*. *Dust* containing all kinds of mineral, vegetable, and animal particles, frequently renders the air impure and irritating to the lungs.

(9) *Domestic animals*, such as horses, mules, camels, donkeys, bullocks, cows, buffaloes, goats, dogs, sheep, etc., kept in and near barracks, houses, and camps, spoil the air, as we do, by breathing. They render the air impure also in other ways. Their droppings, if left on the grounds (as they frequently are, for a time, at least) decay and the foul gases given off in the decaying process pollute the air. Further, when this manure dries up, it crumbles to powder, which mixes with the air we breathe. We see the necessity then of keeping cows, horses, dogs, and other such domestic animals in properly made stables, sheds, kennels, and standings clean and at a distance from the places we inhabit. These sheds should be kept clean.

Every now and again in most of our Indian Municipalities the carcases of dead beasts of burden and other animals give rise to a great nuisance. Where practic-

* See PART IV, *Elementary Bacteriology*.

able all such animals should be buried in dry earth several feet below the surface to leeward of municipal limits. When epidemic disease breaks out amongst animals this is a formidable undertaking. If they cannot be buried, the entrails should be removed and burned, and the interior thoroughly charred by a wood fire. In the presence of a refuse destructor these animals would be quartered and burnt *en masse*.

Effects of accumulated human excreta.—Lastly, and perhaps most important of all, is the impurity of the air brought about by the *accumulation of human ordure near barracks and tents*. The gases given off from foul privies are not only disgustingly offensive, but are dangerous to health. Latrines, therefore, should always be properly constructed and kept clean.

Soil contamination in standing camps.—" Soil contamination, and through it air pollution, in standing camps is only a question of time, and the length of time a camp may be safely occupied by troops, depends largely on the efficiency of its sanitary measures. If proper cleanliness is not maintained, and dangerous refuse be not removed, the frequent transfer of the camp itself to a fresh site becomes imperative." * An insanitary camp in the hot weather is rapidly invaded by a plague of flies, which are not only a highly probable source of infectious diseases, but a serious cause of irritation, discomfort and annoyance. Accumulation of organic matter and dirt on the floors of tents will certainly attract flies. The existence of an unusual number of flies in any camp is substantial evidence of neglected sanitary supervision in that camp, or in its neighbourhood. In most of our Frontier Campaigns, dead transport and other animals create a great nuisance and foul the air excessively (*vide supra*).

Uniform composition of air.—We now know the chief ways by which the air is made impure. We also know something about the composition of the air. Notwithstanding all the foul matters added to air, it remains much the same in composition, and this uniformity is another wonderful provision of Nature ; for, if the air became gradually more impure, we, and all the animal creation, would soon perish. We will now inquire into the factors that are constantly at work in keeping up this uniform composition of the air.

B.—VENTILATION.

One of the great principles of sanitation is to get rid of whatever comes away from the body as soon as possible, be it air fouled by breathing or the waste matters from the body—fæces and urine.

This principle directs that we should get rid of the air we have made impure by breathing and otherwise, as quickly as practicable. We get rid of this foul air, and supply ourselves with fresh air, by what is called *Ventilation*, which means the bringing in of wind. Ventilation teaches us how to remove or dilute the foul air of dwellings by a supply of good fresh air. It tells us how to get rid of the impurities that are given off from the lungs, skin, and body generally, as well as those that arise from vegetable and animal decay, combustion of lights and fires, and from cooking. Ventilation is usually divided into *Natural* and *Artificial*.

Natural ventilation.—*Natural ventilation* is effected by the forces of Nature, and *artificial ventilation* is carried out by appliances and arrangements manufactured and used by man to aid these natural forces. There are three factors at work in producing aerial currents.

* MUNSON'S *Military Hygiene*, p. 402.

These are—(1) The property possessed by all gases of diffusing or mixing with each other;* (2) the fact that warm gases are lighter than cold, and therefore ascend;† and (3) the force of the wind. Let us consider each of these in detail.

(1) All gases mix with each other or diffuse. If two gases in two separate jars are brought into communication, they will diffuse or mix with each other; the same rule holds good regarding ordinary air. The physical law regulating such diffusion is thus expressed—the diffusibility of two gases varies in inverse ratio to the square roots of their densities. We see this by watching the smoke ascend from the chimney of a railway engine; it ascends higher and higher, and as it rises it loses its dark colour and becomes less dusky, because it mixes freely with more and more air or diffuses itself; finally, we see that the smoke seems to have disappeared altogether; at this stage it has completely mixed with the air. That which gives smoke its dark hue is not a gas, it is minute particles of carbon, but these particles are mixed or in company with gases which diffuse freely in the air. In breathing, the same principle is in action. The gases, vapour, and animal particles we breathe out mix readily with the air, and are diluted and the more air they mix with the less harmful are they.

(2) The second factor in natural ventilation is that *warm air is lighter than cold and therefore ascends, and by ascending permits cooler air to take its place below by gravitation.* The warm air rises and floats on the surface of the cool air, just as a cork floats in water because it is lighter than the water. The warm and bad gases in an inhabited room ascend towards the ceiling. If there is an opening at the top of the room, the foul air goes out by it and it is thus got rid of. If there is no such opening, however, the bad air gets cooler, becomes heavy and descends, and we are obliged to inhale it once more. It follows, then, that all barracks and houses should have openings in the upper part of the room to let out the foul air. In India exit of foul air is best ensured by having small windows placed near the roof.

This second factor is the main cause of the circulation of air in rooms. We can easily prove that it is always in action. Thus, if we open the door of a heated room in which there is no cross ventilation, and hold a lighted candle first at the top and then at the bottom, we can see by the deflection of the flame that there is a current of air

* This *diffusion of gases* is based on the well-known physical principle whereby two gases tend to mix in exact proportions, no matter what may be the quantity of each.

† All gases expand about $\frac{1}{500}$dth of their volume for every increase in temperature of 1° Fahrenheit, or $\frac{1}{273}$rd for every degree Centigrade. Air, like all other gases expands; the volume of a given weight of air at a constant pressure is proportionate to its absolute temperature. The temperature remaining the same, the volume of a given weight of air is inversely as the pressure it bears; so much so is this the case that with extreme pressure and very low temperature air may be liquefied.

directed outward at the top and inwards at the bottom opening. The smoke of a piece of burning brown paper, or burning camphor, in front of a fire-place or near a door or window, will indicate that a current of air is passing up the chimney, or in or out of the door or window. This is caused by the difference of temperature between the air in the room and the outside air. All ordinary ventilation depends on this difference of temperature.

Where, as in India, the difference between the inside and outside temperature is so little, the size of the inlets and outlets for air must be considerably greater than in temperate climates, to enable natural ventilation processes to effect a purification of the inside air. This is taken advantage of specially in the morning and evening by opening all doors and windows.

For many months in the year the outside air is much hotter than that within houses, then the outside air draws or sucks air from the outlets, the windows and doors, the frames of which become hot and expand the layer of air in contact with them, while air rushes in, usually from the opposite side, to take the place of the air thus withdrawn from the room.

The first point to ascertain is the amount of cubic space a man requires in a room to keep the air pure. A member of a mixed community breathes 400 cubic feet of air in 24 hours, what sized room do we require for him?

The smallest space that should be given to each person to live in is 500 cubic feet. In a room 10 × 10 × 20 feet we have 2,000 cubic feet of air, and if six persons occupy it, this would give each person 300 odd cubic feet of air-space. To keep this air fresh it would have to be changed nine times in the hour, which could not be effected by natural ventilation without a strong draught, and in India it would be physically impossible as ordinarily the difference of the temperature within and without a house is insufficient to create strong air-currents. Allowing only four persons to occupy such a room with 500 cubic feet of air-space each, the air, with the ordinary ventilation arrangements of huts and small houses, would be decidedly impure. The amount laid down by sanitarians for each person is 1,000 cubic feet of air-space, and this amount should be changed three times in an hour thus allowing 3,000 cubic feet per head per hour. Each occupant should have 1,000 cubic feet of air-space, and 80 feet of superficial space, and be provided with a total inlet and outlet space for air of 2 feet square, that is, 4 square feet. As this in the poorer classes of houses cannot be obtained the smallest allowance should be 500 cubic feet of air-space, and 40 superficial feet of floor-space, with 2 square feet of inlet and outlet area, and when the cubic space is small, the apertures of outlet and inlet

must be large in proportion. In the barracks for European troops each man gets 90 superficial feet and 1,440 cubic feet of air-space on the plains. In European hospitals each patient gets 120 superficial feet and 2,400 cubic feet of air-space.

(3) The third factor is that of the *wind*. It sweeps away bad gases arising from things that are decomposing, brings in a supply of good air, and so keeps the air of rooms fresh and pure. But the wind can only carry out this office by our placing our windows and doors in such a position that it can gain entrance and exit. To get full advantage of it for this purpose, we should have windows and doors placed opposite each other in the room—or better, at an angle to one another—so as to ensure circulation of the air, and thereby prevent its passing directly in and out. But if the windows and doors are placed at an angle to the prevailing winds, they may be opposite one another. The windows should open directly into the outside air.

The air is also to a large extent purified by the action of the sun's rays, by the chlorophyll of plant cells, and by being washed by rain.

Having considered the natural forces engaged in ventilation, let us see how they are taken advantage of. All openings in a room, hut or tent communicating with the air, directly or indirectly, give entrance or exit to air. The chief of such openings in rooms are doors, windows, and chimneys, and in tents' doorways, side-walls, and in some instances small windows. But all chinks and cracks in doors, windows and walls effect the same object. Openings in the roof, such as exist in some ridge-roofed houses, do the same. Even brick walls allow some air to get through them, and thatched-roofed houses freely permit of air making its way from rooms.

We have said enough to show that every occupant of a house should be supplied with a sufficient quantity of fresh air.

Ventilation is perfect only when the air in a room or tent is as pure as that out of doors. This could be effected with 600 cubic feet of space for every occupant, if the *best possible* arrangements for change of air existed; but such arrangements are rarely found, at least, in India. Thousands of lives are sacrificed yearly in all classes of the community through neglect of ventilation—especially amongst the labouring and industrial classes. It often happens that, in the huts of the lower classes, not more than 300 cubic feet of air-space is provided for each person. A large number of women in India are obliged to live the greater part of their lives in one or two small ill-ventilated rooms. The *zenana* houses or huts of some of the poorer classes are as bad as dungeons. In them an unfortunate woman is confined to one small room day and night. As a rule, no provision is made for either ventilation or access of light. We were once asked to see a woman who was suffering from cholera; she was found occupying

a room $6' \times 7' \times 6'$ and in this small chamber three other women and her husband were crowded. Two of the other women and the husband subsequently succumbed to that disease

It is very necessary for the good of future generations in India that *gosha* or *parda-nashin* women should be provided with enough air and light. The present system tends to bring about a gradual lowering of the strength and vigour of such females, which renders them unable to go through the natural processes when offspring arrives. Further, such offspring is frequently puny and defective in development, and, under existing circumstances, may become by degrees more so.

As artificial ventilation of houses is not adopted in India, natural ventilation has to be facilitated by properly arranged large-sized doors and windows. In the houses of well-to-do people in India ventilation as a rule is a matter that looks after itself. Windows and doors are usually in sufficient numbers. In the houses of poor people, as we have already stated, this is not the case. It is desirable that every house and hut in India be provided with large windows capable of opening completely.

Another object of ventilation is to provide enough fresh air *without the creation of draughts.* This can only by effected when the amount of cubic space * is sufficient. Air can only be kept in a state of purity when 3,000 cubic feet of air is supplied to each person every hour. The air in a room should be changed about three times in an hour, otherwise draughts or perceptible currents of air are created. The air in a tent must be changed more frequently than in barracks, for in barracks on the plains each European soldier gets 1,440 cubic feet of air-space and each Native soldier 810 cubic feet, while they also get 90 and 60 superficialfeet of floor area respectively. Therefore 1,000 feet of cubic space should exist for each person. Such an amount of space, however, cannot always be furnished, but we consider that 400 cubic feet is the least

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* *Cubic space* refers to the actual volume of air contained in the room. In roomt with the walls, floor, and roof at right angles to one another the cubic space is gos by multiplying the length, breadth, and height together. In estimating cubic space the volume occupied by bedsteads, cupboards and other articles of furniture, and by permanent projections of the building into the room should be deducted from the total cubic space, and the volume of air contained in recesses should be added to the total cubic space. The cubic capacity of such projections and recesses should be calculated separately. The same may be done regarding the air-space in the upper part of the room when the roof is not horizontal In rooms where the floor, walls, and roofs are at right angles to one another the calculation of floor space = length × breadth, and the cubic capacity = floor space × height. In other cases the cubic and superficial area are found by the following rules: —Area of triangle = base × height × $\frac{1}{2}$. Area of irregular four-sided figure divide into two triangles by joining two opposite angles. Find the area of each triangle and add together.

Area of circle = $(\text{Diameter})^2 \times 0{\cdot}7854$.
Area of semicircle = $(\text{Diameter})^2 \times 0{\cdot}3927$.
Area of an ellipse = Long Diameter × Short Diameter × 0·7854.
Capacity of a dome = Area of base × height × $\frac{2}{3}$.

allowable. Each person should have about 90 square feet ot *superficial space* * and under no circumstances should it be less than 48 square feet. The superficial space is not of very great importance so long as the air can be changed often enough to keep it pure; but if the air is changed too often it causes a draught, which may (especially in cold weather) bring about chills and fever. Even with a large superficial space, if there be not proper ventilation arrangements, the air remains impure, whereas with small surface space, if the ventilation arrangements are good, the air may be kept pure.

Even the small cubic space above-mentioned (400 feet) is rarely provided for each person in *bustee* huts. We see large families huddled together in one small room and this occurs in the huts of entire areas, leading to dense overcrowding. It is now a well-known fact that people in over-populated places die much faster than those in less crowded localities.

A simple way of testing the effectiveness of ventilation in a room is to take a bottle $10\frac{1}{2}$ ounces in capacity, which has a good stopper. Fill it with distilled or boiled water, then empty it in the room, pour in half an ounce of lime water, replace the stopper, shake up the lime water and if it becomes milky the ventilation is insufficient.

Ventilation of sleeping-rooms.—It is very important that we should be supplied with good air in the room in which we sleep. It must be remembered that we pass about one-third of our lives in sleep. Some of our Native troops are disposed to close all the doors and windows of barracks and all tent doors at night during all weathers. By this the good air is shut out and the bad air kept in the room or tent. The result is that the occupants get up in the morning feeling lazy, heavy, and disinclined for their day's work, instead of being fresh and active. If we go into such a room in the morning, before the sleepers are awake, we find the air oppressive and offensive. By sleeping in a room where but little fresh air enters foul air is being constantly breathed and re-breathed. We know that the animal impurities and carbonic acid gas thus inhaled are injurious. We should, therefore, always provide for the entrance of abundance of fresh air into sleeping-rooms, avoiding cold winds and draughts. This enables us to sleep better, and to awake refreshed. The body should, of course, be kept warm with a sufficiency of bed-clothes in the cold weather to prevent chills. We must keep our bodies warm with bed-clothes, if necessary, to avoid chills. In all cases where there is a top window or ventilator in the room, it should be kept open.

It is necessary also that barrack-rooms and tents be supplied with abundance of fresh air in the daytime. During the day the men

* *Superficial space* means the extent of the flat surface of the room, and if the sides of the floor are at right angles, it is got by multiplying the length into the breadth

are for several hours outside and in the open air. The doors and windows should always be opened during this time except when actually raining, and even then one or other side can usually be kept open.

Effects of re-breathing air.—By breathing, we rapidly spoil the air. A mouse placed in a wide-mouth bottle closed with a good glass or rubber stopper dies in a short time, chiefly from want of oxygen and breathing carbonic acid gas and animal impurities. If we are shut up in a place where the good air from outside cannot enter and the bad air from within cannot make its exit, we soon become ill; and if we remained long under these conditions, we should die. We have all heard of the Black Hole of Calcutta. This was a small room in which 146 persons were placed for a whole night, the room having but two small windows, which were closed. During the night, the people suffered intense agony, and in the morning only 23 of them were found alive, the other 123 having died from the bad effects of air that had been breathed over and over again (see p. 157).

Punkahs.—*Punkahs* are real accessories to ventilation. They cause the speedy removal of watery vapour from the skin and thereby cool the latter, dilute and remove the expired air, and also at each swing force a blast of air out of all openings on one side of the room, which necessitates fresh air entering by openings at the other side, and the stiller the air the more effective is their action in this last named way.

The cooling effect of the punkah alluded to is due to the constant change of the air in immediate contact with the skin which facilitates evaporation of the sensible and insensible perspiration, and helps the abstraction of heat from the surface so long as the air in the room is colder than the skin, and is not itself saturated with watery vapour.

Tatties and Thermantidotes.—These work in the summer in the barracks of some stations and by them the occupants may be rendered more comfortable. *Tatties* are screens made with *khas-khas* grass which is kept constantly wet with water sprinkled on it. These screens exactly fit the doors and windows and are watered either by some automatic arrangements or by a coolie throwing water over them periodically. The hot outside air in passing through the tatties gives up its heat and causes evaporation of the water, thereby cooling the air passing through it.

Another method of carrying out this is by means of *thermantidotes* which are revolving wheels with fan-like spokes of *khas-khas*, the whole being enclosed in a wooden case. The tatties of the thermantidote may also consist of circular pieces of *khas-khas* adapted to the sides of the wooden case, the spokes of the wheel being thin flat pieces of wood. In either case the *khas-khas* is watered from outside. The mouth of the thermantidote fits into a wooden framework

adjusted to the door or window, the ordinary door and window being removed to permit of this being done. It is not wise to work in a room into which a thermantidote opens directly, as the temperature of the room may be considerably lowered and render the occupants liable to chill. If used it should open into a room adjoining and communicating by a door with that in which we are working. One has been in a house in Hyderabad (Deccan) in May, in which the air at the mouth of the thermantidote was found to be 76° F., when the verandah temperature was 99° F.; so apparently cold was that particular room that the residents sat in an inner room communicating with it, the temperature of the inner room being 86° F.

Electric fans.—Electric fans are superior to punkahs in that their action is uniform, and not subject to variation as to the amount of air set in motion. They undoubtedly add considerably to one's comfort. They also obviate the necessity of employing punkah coolies who are a sore trial to the temper in the hot weather, and are frequently the harbourers of malarial parasites.

FOOD.

A.—Classes of food-stuffs.

The method of feeding the Army is a very important factor as regards efficiency, and all ranks should be familiar with the main points which should regulate the selection of certain foods, their method of preparation, digestion, their uses in the economy, and the various diseases that might arise from defective feeding.

Importance of proper food on field service.—The food of the fighting soldier is one of the most important concerns of a campaign, and its importance grows with the length of a campaign. Defects in the field diet as a rule take some time to develop their evil consequences. The bad results of—a diet deficient in quantity, defective in quality, lacking in variety, unbalanced as to the *proximate principles* * required for the normal physiological working of the fighting man's economy, improper preparation or defective cooking, etc., sooner or later manifest themselves. In one or more of these ways the factor of diet may affect the fighting capacity of a force. Accidental errors in diet, or at times the eating of certain articles of food, may, on field service as in peace times, produce their effects abruptly in the form of acute indigestion, colic, diarrhœa, acute food-poisoning, etc., but this is an exceptional occurrence and need not be here taken into account.

* The different substances entering into the composition of any article of food are conveniently referred to as *proximate principles*, "because consisting as they do of carbon, hydrogen, oxygen and nitrogen, combined more or less with highly complex bodies, they are really elementary constituents or proximate principles of the human organism."

What is a food.—A food in a wide sense is anything that aids in keeping up the form and action of our bodies under all conditions of life. Everything which goes directly or indirectly to the growth or repair of the body, or to create force, motion, or energy in any form, may be called a food. Defined in this way, foods include all solids and liquids consumed and the oxygen of the air we breathe.

Before entering upon a consideration of the actual foods used, it would be well for us to acquire some general knowledge regarding the uses of food, how they serve to purposes of the economy, and subsequently to consider the manner they are prepared for digestion and assimilated, the way in which food may be harmful, and the conditions that determine the dietary used. Finally we will deal with the various beverages we consume.

The chief part of the food of man is obtained from the animal and vegetable kingdoms. The complex organic compounds necessary for the food of man cannot be constructed out of the simple elements. When these compounds gain entrance into the system, they form others which fit them for the purposes of man's economy. They cannot be formed from the mineral or inorganic kingdom There are no arrangements in the lungs for utilising the nitrogen of the air to supply us with this element, as there is with regard to oxygen. Nor can we digest, absorb, or utilise a solid piece of charcoal to provide the quantity of carbon needed. To plants alone is given the power of forming compound organic bodies out of the inorganic kingdom. Nearly all our food, therefore, must come directly from the vegetable world, or indirectly from it through lower animals.

Need of food.—Man, as well as all things living, is always doing something—always at work. Much of the work we do is visible—such as standing, walking, running, lifting weights, swimming, playing outdoor games, etc. This is called *external work* or visible energy. Many actions however go on without notice, such as breathing, the beating of the heart, and the action of the brain. The energy expended in these unnoticed actions is called *internal work*.

The healthy body is perpetually working and wasting; every act performed means so much waste of tissue. With this waste there is wear and tear and the formation of effete products, which the body has to get rid of. These are thrown off by the lungs, skin and kidneys.

All this waste of tissue is associated with oxidation processes, or a slow burning which is going on within the body. In this oxidation the lungs, skin and kidneys throw off daily from the system about 4,000 grains of carbon in the form of carbon dioxide, and about 250 grains of nitrogen in the form of urea.*

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* *Urea* is the chief nitrogenous constituent of the urine. It is composed of carbon, oxygen, hydrogen and nitrogen, and is the form in which the greater part of the waste nitrogen of the body is excreted.

While oxidation is going on properly in health, the body remains at a more or less constant temperature. Without these oxidation processes the body gradually becomes colder. After death the body loses heat and becomes quite cold.

To repair this constant waste of tissue in the body food is required. Food contains the carbon, hydrogen, nitrogen and oxygen and other elements needed to make up the loss. A man of average weight during the course of the year ingests about a ton (or 2,240 pounds) of food and liquid.

Functions of food.—The food we consume subserves four special purposes:—

(1) The production of energy; (2) the production of heat; (3) the repair of waste produced by wear and tear of the tissues and cells of the body; and (4) the building up of new tissues or materials.

Before the food can reach the tissues and organs of the body it must be greatly changed. To understand how this change is brought about, we must know something regarding the nature of foods, and the apparatus by means of which this change is effected.

Classification of foods.—*Foods are of various kinds.*—To enable us to have some idea as to the essential qualities of foods, it will be necessary for us to classify them in a simple way and to briefly describe the chief articles of diet contained in each class.

Foods may be divided into two classes—*Inorganic* and *Organic*. Everything we eat or drink belongs to one or other of the following divisions:—

Inorganic.

Water.
Mineral matter, as common salt.

Organic.

Proteid, nitrogenous, or albuminous (flesh-forming foods).	Albumen, which occurs in meats and eggs. Fibrin, which occurs in blood. Gelatin, which occurs in bones and connective tissues. Casein, which occurs in milk. Gelatin, which occurs in cereals.
Non-nitrogenous (heat and force producers).	Hydrocarbons, as in oils and fats. Carbohydrates, as in starches and sugars.

To the *Organic* division we shall add another class, known as *Accessory Foods;* but it should be remembered that these accessory foods are not absolutely necessary for maintaining the body in health; they are *luxuries*.

Water.—We have already considered the more important facts in connection with the subject of water. We need here only say a few words regarding its function as a food and solvent. Our tissues and organs contain a large proportion of water, part of which is free and uncombined, the other part is in close combination with them. One part soaks and imbues the tissues, the other forms part of their structure. An adult man when doing a moderate amount of work requires about 46 ounces of so-called dry food to keep him in health. About one-half of this consists of water, so that only about 23 ounces is solid, dry food. As average adult loses from the skin, kidneys and lungs, about 80 ounces of water daily. He requires, therefore, a similar quantity to make up for this loss. Some foods contain a large amount of water. Beef or mutton contains 72 per cent. of water; in other words, 1 lb. of either of these consists of about 12 ounces of water and 4 ounces of dry solid meat; bread 38 per cent. Vegetables contain from 85 to 98 per cent. Such articles as turnips are almost all water; fresh fruit is much the same in this respect. Butter contains 16 per cent. of water.

Purposes served by water.—Water acts as a general solvent, by means of which property it serves to convey nutriment to all parts of the body. So long as water is taken the absence all other food can be borne for a comparatively long time. When deprived of food and water, it is thirst we feel most and soonest. This thirst is felt in the mouth and throat, but this is merely a local sensation expressing a general want—a demand, on the part of the body, for fluid. Water is equally necessary for the removal of waste matter from the body.

Mineral matter.—The only mineral matter for which man craves is salt. This he takes as a regular article of diet. The other forms of mineral matter that he requires are taken in sufficient quantity with the other classes of foods—albuminous or nitrogenous, and vegetables. Many substances, however, as rice, sago, and arrowroot, contain scarcely any mineral matter, whereas others, such as meat, fruit, and vegetables, abound in them. The desire for common salt arises from the fact that it is necessary to all the important fluids of the body, and especially to the blood; it also forms an important part of the *gastric juice*. Mineral or saline matter is, therefore, required in the body, but it is required in varying quantity for the tissues and fluids. *Potassium salts* are contained in the blood and muscles; *lime salts* are necessary for the formation of bone, and both these forms of mineral matter are present in many kinds of animal and in some vegetable foods. *Iron*, which is required in the formation of the red blood cells, is also contained in some of our food-stuffs.

Certain diseases are supposed to arise from deficiency of lime in the salts of the blood. The bending and enlargement of the ends of bones met with in some children is said to be due to this cause. The disease in which these are met with is called *rickets*.

Nitrogenous, proteid, or albuminous food.—This is the class of food which serves to furnish us with the nitrogen required for building up the tissues of the body. The principal foods of this class are obtained from the flesh of animals killed for man's consumption. But many vegetable foods also contain it; for instance, we have a nitrogenous body in beans, peas, and *dal,* called *legumen,* which forms the chief source of nitrogen in all vegetable-eating races.

Proteids are by far the most complex class of foods and can only be obtained from either animal or vegetable structures. They are all rich in one or more of the following organic compounds—albumen, casein, fibrin, gelatin, myosin, gluten and legumen.

Albumen is typically represented in white of egg. When an egg is boiled the outer part becomes of a white colour. The liquid part of the blood called *serum* contains a large amount of albumen, as do all flesh meats.

Casein is the main constituent of cheese and the chief part of the curd of milk.

Fibrin is largely contained in the blood and in muscles. In many respects it is like albumen.

Gelatin enters largely into the composition of gristle, bone and skin, and these yield it up on boiling. The calves' feet jelly made in the sick-room consists largely of this material.

Myosin is one of main constituents of muscle fibre of flesh of animals.

Gluten is vegetable fibrin, and is contained in grain foods, such as wheat, maize, Indian-corn, etc.

Legumen resembles casein and is often called vegetable casein. It is the nutritive part of peas, beans, and *dal.*

All these materials contain carbon, oxygen, hydrogen and nitrogen; they are, however, particularly rich in nitrogen, hence they are called *nitrogenous foods.* Peas and beans contain them largely; they are to a less extent contained in wheat-flour, atta, barley, oatmeal, etc.

Proteid or nitrogenous food-stuff is essentially necessary for nutrition. It is the only proximate principle which cannot be excluded from the diet. We could live on meat alone if taken in sufficient quantity, but it would not be economical to do so, and it would tax the various functions of the body to get rid of the excessive amount of harmful waste products formed during its digestion and assimilation. The meat would contain an excess of nitrogen, and is too poor in the other classes of foods. Alone it is not sufficient to keep the body in a healthy state for any length of time. On the other hand, we could not live on any other class of food. Starch, sugars, and fats contain carbon, hydrogen, and oxygen, but no nitrogen. A number of dogs were fed on an entirely starch diet for some months. They then died from symptoms similar to those met with in death produced by starvation. This form of death is called *nitrogen starvation.* Some proteid must be added to the food-stuff, which may be supplied from either the animal or the vegetable kingdom. Some of the cereals, especially wheat-flour and maize (*bajra*), contain a comparatively large amount of nitrogenous matter, called *gluten.*

Decrease of nitrogenous material in food leads to a lessening of the oxidisable albumen in the blood (*circulating albumen*), impairment of energy and stamina, and decrease of weight.

When excess of nitrogenous material is absorbed into the system, it may lead to defective oxidation, giving rise to excess of uric acid * in the body. It may also lead to engorgement of the liver, full-bloodedness, diarrhœa, and after some time to a gouty condition of the body. In cold climates, there is naturally greater muscular activity than in hot climates, and this helps in using up the unoxidised products which arise from an excess of nitrogenous material in the food. Hence Europeans coming to India should eat less nitrogenous food than they do in Europe, especially during the hot weather.

Muscular exertion calls for but little increase of nitrogenous food. The urea discharged (which represents the oxidation of the circulating albumen in the blood and the wear and tear of the tissues) is but little increased under excess of physical exertion.

Functions of nitrogenous foods.—The chief functions of proteid or nitrogenous foods are:—To repair the waste and the wear and tear of the body and build up the tissues; to some extent they furnish material for combustion or oxidation, by means of which the temperature of the body is maintained, but for this latter purpose they are not as suited as other classes of foods; they also regulate the processes of oxidation in the body.

Nitrogenous food is supplied as meat, eggs, milk, or leguminous foods. As a rule, we consume only the flesh of animals that live on the products of the vegetable kingdom, although some races will eat anything from a snake or dog to a man.

Starches or carbohydrates.—About two-thirds of the food we consume consists of starches or carbohydrates; it includes the several varieties of starch, sugar, and gum met with in the vegetable kingdom, which contain practically no nitrogen; they are principally contained in what are called cereal grains. They form a most important part of our main food-stuffs. At any one time the amount of carbohydrate material actually present in the body is small.

Starches and sugars are all compounds of carbon, hydrogen and oxygen, and are called *carbohydrates* because their chemical formula contains twice as many atoms of hydrogen as of water, or carbon + water.

Although all the various cereal grains look very different from one another, they all possess a large proportion of starch, which consists of granules made up of layers one covering the other, the outer layers

* *Uric acid* is an organic body which is excreted by the urine and through it a small quantity of the waste nitrogen of the body is got rid of. It contains C, O, H and N.

being the harder. This external layer is called the *cellulose envelope.* These granules, when subjected to heat by boiling, swell up, burst the outer covering and form a gummy mass, which on cooling becomes jelly-like. This action of heat is necessary to enable the digestive juices to act on the grains of starch. Until this action takes place starch, as an article of diet, is useless. The saliva contains a body called *ptyalin* which converts starch into a form of sugar called *grape sugar.* Starchy food should be slowly masticated in order that all parts of it may be thoroughly mixed with the saliva. Starches enter largely into the composition of flour, *atta, bajra,* etc. Rice consists almost entirely of starch.

Grape sugar (glucose) has a molecular chemical formula of $C_6 H_{12} O_6$, cane sugar $C_{12} H_{22} O_{11}$, starch $C_6 H_{10} O_5$. Chemically there are many varieties of starch having the general formula $(C_6 H_{10} O_5)\,n$, the n representing a varying number of molecules in each form of starch.

In the oxidation of the sugars or carbohydrates oxygen is only required to oxidise the carbon as the hydrogen and oxygen exist already in the exact proportion to form water. This is shown by the common chemical formula for sugars, $C_6 H_{12} O_6$, which might be, in this sense, represented as $C_6 (H_2O)_6$. With fats more oxygen is needed to completely oxidise the hydrogen as well as the carbon.

Starch is widely diffused through the vegetable kingdom. It occurs in Nature in the form of microscopic grains, varying in size, shape, and appearance, according to their source (Figs. 26—31).

FIG. 26.—Wheat starch.

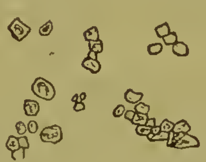

FIG. 27.—Rice starch.

FIG. 28.—Potato starch.

F. 29.—Bermuda arrowroot starch.

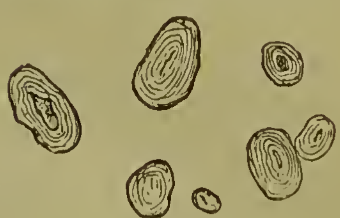

FIG. 30.—Pea starch.

FIG. 31.—Bean starch.

Each consists of a central spot, round which more or less concentric envelopes of starch proper (granulose) alternate with layers of *cellulose*.* Although the various cereals look very different from one another they all possess a large proportion of starch.

Starch itself is insoluble in cold water, but boiled with water, it swells up and forms an incomplete opalescent solution which if concentrated gelatinises on cooling. When iodine is added, it turns blue. When acted on by saliva or pancreatic juice, it is converted into a watery fluid (*hydrolized* †), first forming dextrin and then grape sugar (dextrose).

Before the formation of dextrin the starch solution loses its opalescence, a substance called *soluble starch* being formed.

The large class of carbohydrates includes *sugars*. There are different kinds of sugar: the one we daily use is *cane* sugar, yet all varieties of starch and sugar, before entering the blood, are changed into grape sugar. It is in this form that all starches enter the blood, for grape sugar is readily dissolved in the juices of the alimentary canal and easily passes into the blood vessels. A due proportion of ordinary sugar is a wholesome addition to our food.

Sugar is also contained in many other articles—in fruits, as oranges, grapes, water melons and marsh melons, beet-root, plantains, and also in the flesh of animals in the form of glycogen.

The principal use of starches is to *produce heat*. In some cases they are changed to fat.

Fats or hydrocarbons.—Hydrocarbons or fats are contained in both the animal and vegetable kingdoms. We get butter and ghee from the milk of the cow, and solid fat or suet from slaughtered animals; from plants we get vegetable oils. This class forms a very valuable part of our diet, as it helps us to utilise the other foods inside the body. They are almost as necessary to a healthy dietary as the proteid matters. Fats are compounds of glycerine with fatty acids. There are three chief fats in the human body, called *stearin*, *palmatin* and *olein*, which are built up from three corresponding fatty acids.

The preparation of a fat, previously to its absorption, occurs in three stages. It is melted, emulsified,‡ and split up into glycerine and fatty acids. Only the fats which are liquid at the temperature of the body are at all readily absorbed.

All fats and oils, both animals and vegetable, contain considerably less oxygen in proportion to the amount of their carbon and hydrogen—*stearin* has a formula of

* *Cellulose* is the colourless material of which the cell wall of plants are composed.

† *Hydrolysis* is the process by which the molecule of a body unites with water and then breaks up into smaller molecules.

‡ Emulsification consists of splitting up fat globules into fine particles the advantage of which is to permit the more complete action of the fat ferment of pancreatic juice (steapsin) to allow of direct absorption into the cells of the villi (*vide* section on *Digestion*).

$C_{21}\,H_{40}\,O_6$. Although carbohydrates are more readily assimilated than fats, they are 40 per cent. less nourishing. The fats chiefly serve the purposes of heat-production and mechanical energy in the body. When taken in due proportion with the other *aliments*, they help digestion and assimilation of the other classes of foods. If fatty matters are taken in excess, they are then deposited in the body or lead to indigestion and are discharged unused. The fats taken as food are not, however, simply deposited in the body as fat, but are more or less changed before being so deposited.

The fats and carbohydrates of food provide the body with the oxidisable material required for the production of heat and force; and they are finally thrown off as carbonic acid and water. They help in the nutrition of the tissues and in the excretion of waste products. The amount of fat in the diets of European soldiers is deficient—this applies to not only our own Army but to that of all European countries.

An excess of either fats or starches decreases the oxidation of nitrogenous matter, and leads to the accumulation of fat in the tissues. A deficiency of either causes an increased metabolism of circulating albumen, defective nutrition, and loss of weight.

If fats or starches are withdrawn from the food, the nutrition is eventually interfered with, although to some extent they are interchangeable. This latter fact is demonstrated in the diet of the Esquimaux which contains but little carbohydrate.

Assessory Foods.—*Luxuries.*—There are certain foods (the use of which we are only imperfectly acquainted with) classified as *accessory foods.* They include a long list, amongst which are tea, coffee, condiments, alcoholic beverages, etc. We could probably do without them, yet they appear to be useful in some ways; in short, they are not indispensable—they are luxuries. Some are used by the nervous system, especially tea and coffee. We know by experience that a cup of strong coffee or tea frequently removes muscular and mental weariness like a charm. An excessive use of condiments, highly seasoned sauces, cayenne pepper, Indian chillies (as in pungent curries), etc., is harmful to the stomach and digestive system generally.

Some of these accessory foods subserve the functions of *nutrition* in the body; others, as we shall see in a later page, assist digestion.

Change of food into tissue—Metabolism.—Metabolism means the various chemical reactions carried on by the living cells of the body, whether the material acted upon is part of the cells themselves, or merely lying in contact with the cells. A study of metabolism seeks to ascertain the chemical changes forming the bases of the working capacities of these living cells.

The food-stuffs, plus the oxygen of air, are the sole supply of chemical energy available. The chemical changes that occur in the food-stuffs may to some extent be followed from the time they are eaten to the time they form part of the living cells and tissues, and to a certain extent we can also trace the changes that occur in the breaking down of these cells and their repair, and the manner in which the products resulting from such breaking down, are removed from the body by the organs of excretion. The total amount and general charaeter of these chemical changes is ascertained by comparing the amounts and nature of the food-stuffs consumed on the one hand, and of the excretory products on the other.

The extent to which the food-stuffs consumed are made use of in the body is important, *e.g.*, the proteid of vegetable foods is largely wasted.

In all cases there is a limit to the amount of any particular class of food that can be digested and assimilated, *e.g.*, if too many eggs are eaten, some of the excess of albumen is absorbed and thrown off by the kidneys in the urine, and the kidneys may be damaged in the process; if too much starch food is taken, sugar appears in the urine. In these cases the powers of assimilation has been overstepped. Usually however, when such excess is indulged in, it is defectively digested. Except in the case of infants and very young children, the food must be adapted to the age of the individual, the amount of work done, and the climate. In children the proteid should be in relatively greater excess, and the chief carbon containing food may be reduced.

B.—Description of the Chief Nitrogenous proteid or albuminous foods.

Animal nitrogenous foods.—In this category are included those animal foods which contain substances rich in nitrogen, such as *albumen*, *gelatin*, *fibrin*, etc.; these are the *flesh* of animals, eggs, milk and cheese.

The value of different kinds of flesh food depends on the amount of nitrogenous and other matters they contain, and upon the ease with which they can be digested. All flesh contains a large proportion of water, and a varying quantity of fat—even lean meat contains fat mixed up with the muscle fibres. The nitrogenous principle or proteid of all flesh food is in the lean part of the flesh.

Beef.—The flesh of the cow is very nourishing, but, being of firm texture, it is less easy of digestion than mutton. The older the animal the denser is its flesh, the harder is it to digest, and the less the nutritive matter it contains. Cow beef is inferior to ox beef.

Good beef is firm to the touch, does not pit on pressure by the finger, is not coarse in texture and has a moderately bright red colour; it should not be too pale a pink nor too dark a red; it is marbled with streaks of fat running between the muscle bundles. It contains less fat and more proteid than other animal foods weight for weight. It is also richer in flavour and contains more blood juices. The best prime beef is from an ox about four years old.

As beef is frequently affected with "measles"* it should always be thoroughly cooked before being eaten. The writer once served in a

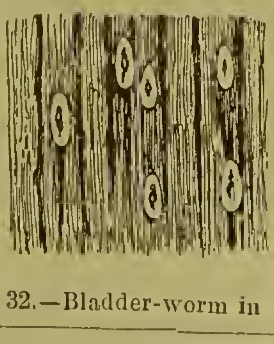

Fig. 32.—Bladder-worm in beef.

* This is a form of bladder-worm disease affecting cattle; these bladder-worms occur in the muscles of the diseased animal, looking like small round or oval peas scattered through the flesh, and are the embryocs of the form of tapeworm which affects man, if he eats the partially cooked flesh of an animal affected with "measles."

large military station in Northern India where nearly 70 per cent. of the cattle slaughtered for European troops was "measly."

In *veal* as used by Europeans, the flesh is white, as the animal is completely bled ; this bleeding renders the flesh dry and juiceless and wanting in nutritive value. It is digestible and much appreciated as an article of diet by Europeans.

Fat oxen have about 33 per cent. of fat, and fat calves about 16 per cent.

Live oxen should not be under two nor over five years old ; heifers and cows should not be under two nor more than four years old. The most suitable animals for food of troops are those that are moderately fat. Very fat meat loses much of its weight in cooking.

About 15 per cent. of butcher's meat is made up of bone, gristle and other parts that are not eatable.

The nutritive value of meat varies with the age of the animal, its state of health and the amount of fat in it. Prime meat has more proteids and less connective tissue than animals that are too old, too young, or diseased.

Mutton.—If mutton is good it is easy of digestion. It is very nutritive, but has less flavour, and is less stimulating than beef. It is best when the sheep is about three years old. The average amount of bone in mutton is 25 per cent. of the carcase. The fat is less than 15 per cent., but in very fat sheep it may be as much as 50 per cent.

Mutton is less red, and the fat whiter and more solid, than that of the ox. The feet ("trotters") should remain attached to the carcase to enable us to recognise at once that it is not goat's flesh. The best parts of mutton are the legs and shoulders ; wether mutton is greatly prized.

Lamb is more watery and less nutritive than mutton. It is, however, a delicacy that is much prized for the table. Fat lambs have about 33 per cent. of fat.

Goat's flesh.—This has a peculiar goaty odour ; it is darker, has a smaller proportion of fat, and is less nutritive than mutton. The shanks of the fore and hind legs are very thin, the ribs white, outer coat of the carcase deep red, neck very thin in the nanny-goat and very thick in the he-goat.

Bone.—The meat purchased should not contain an undue proportion of bone. Bone itself is, however, nutritive material. Bone contains an albuminous principle called *ossein*, which is highly nutritious. If a quantity of bone is boiled for some hours and set aside it will, on getting cold, be found lying in a mass of solid jelly-like material. This is the *gelatin* which has been abstracted from the bones by the

boiling; about 6 pounds of bone are equal to 1 pound of beef. This material is not abstracted by any method of cooking meat except when made into soup or stews.

The *kidneys*, *heart*, and *liver*, when carefully cooked so as to retain their juices, are very nutritious. When once cooked, they are hard, insipid, and indigestible. *Tripe*, which is the first part of the stomach of the ox is the most easily digested and the most nutritious of all animal food; it is also very savoury.

All stored meat, cooked or uncooked, should be kept in a thoroughly clean place, and the access of animals of all kinds, flies and other insects prevented. This is best effected by putting it into a *dooly* which is an elongated meat-safe, having perforated metal or wire gauze sides all round, suspended in an open airy place out of the sun, or in a well-ventilated larder.

Signs of a healthy animal.—The healthy live animal looks well nourished and not emaciated, walks freely, its eyes are clear and bright and never dull; it breathes freely without noise, its breath is not offensive, its mouth and nostrils are moist and cool and free from any discharge; the coat is smooth, free from eruptions, and not rough and staring; the animal should not be shivering or apparently in pain; it should not have diarrhœa, and when slaughtered, the organs should be normal.

General characters of healthy flesh.—The flesh of slaughtered animals should be elastic and firm, and neither too pale a pink nor too dark a red; the fat should be solid and firm, fairly white in colour, and present no sign of bleeding in it; the meat should have a pleasant fresh smell, and, if necessary, a knife may be plunged into the fleshy part and the blade smelt; this brings out even early tainting.

Inspection of slaughtered carcase.—In the case of the slaughtered animal we should see the internal organs and note if they are healthy or look congested, contain visible animal parasties, collections of pus, etc. If the internal organs have been removed, and the carcase only is left, we should note the condition of the chest wall, pleura, diaphragm and lymphatic glands. The loose tissue in the flanks, under the shoulders and arms, beneath the midriff, and about the kidneys, should be examined for collections of pus or dropsy. The flesh should be examined for bladder-worms, and the under surface of the midriff for any shiny spots which indicate certain parasites. If a carcase is ill-bled, bile-stained, has patches of bloody colour, and the internal organs are dark-coloured and look inflamed, some infectious disease has existed.

If it is necessary to keep meat for, say, 24 hours in the hot weather, this may be safely done by suspending it in an ordinary packing case box with a good fitting door and a hook to suspend the meat from, and burning a few sulphur pastilles inside. "The pastilles may be made from—sulphur 2 pounds, powdered charcoal 1½ ounces, and saltpetre 2 ounces. These are mixed with just enough gum water to make a paste and enable the pastilles to be made into a conical shape. A few pieces of paper pasted on the joints outside the box make it air-tight. Now suspend the meat, place two or thee pastilles on the floor of the box below it, light them, close the door securely and leave well enough alone."*

* "Wyvern's" *Culinary Cuttings for Madras.*

The liver, heart, lungs and flesh are the chief structures in which animal parasites are to be found ; the head, stomach and intestines are the chief regions in which specific infectious disease is shown. Diseased internal organs and diseased flesh when condemned should be destroyed and not sold as dog food.

Age of animals as affecting quality of meat.—In general terms it may be said that the flesh of young animals, although tender, is less nutritive, is flabby and more tasteless than that of older animals. The flesh of an old beast is hard, tough, and without much flavour.

Inspection of live animals and meat.—In cantonments, all animals intended for human food should be examined before being slaughtered by some responsible official who can diagnose the commoner diseases which render these animals unfit for food, and subsequently the carcases should be inspected by this official who should condemn any diseased flesh met with. The butchers should not be allowed to make away with the internal organs before this inspection, as these organs often form an important guide as to the nature of diseases the animals suffered from.

Animals may be killed when suffering from acute infectious or inflammatory diseases when the flesh or internal organs or both are full of parasites. It is a safe rule to condemn all carcases of animals that show that the animal previously suffered from acute inflammatory infectious disease, chronic disease, parasitic or cysticercus* disease, and the meat should be destroyed.

All butchers know when their animals are ill, and that it is wrong to kill them for human food in this state. As a rule, serious disease can be recognised in animals ; each disease has its own naked eye characters when the carcase is hung up, though sometimes microscopical examination of the flesh is necessary to complete the diagnosis.

Meat decomposes rapidly in the hot weather and should be eaten when quite fresh, that is, on the same day as the animal is killed.

Characters of decomposing meat.—Meat in a state of decomposition is at once recognised by its pale colour and offensive odour ; this odour is more pronounced when the meat is cut up and put into hot water, and if lime water is then added an ammoniacal and very disagreeable smell is given off. Meat in any stage of putrefaction, no matter how early, is liable to set up acute irritation of the stomach and bowels, and other manifestations of poisoning, such as vomiting, diarrhœa, cramps, prostration, pyrexia, with weak and irregular pulse. Meat in the early stage of decomposition is often more poisonous than that in a much later stage. On the other hand, game birds and venison in a "high" state does not cause poisoning. The Burman appear to eat *gna-pi* (rotten fish) with impunity.

* "Measles" or bladder-worm disease.

Meat poisoning would seem to depend not upon the number of bacteria present in the meat, but upon the particular species of bacterium, and its products or *ptomaines.* The ptomaines formed by these micro-organisms in animal flesh are not destroyed by cooking, and with these ptomaines there may also be bacteria which have not been destroyed by cooking. A long incubation period after eating the meat is usually associated with bacterial infection, and a short period with ptomaine poisoning.

Meat Poisoning.—Outbreaks of meat poisoning frequently occur in India, and most of them are due to infective organisms resembling those of the common colon bacillus, which is a normal inhabitant of the intestine. Many forms of bacilli have been found in such meat, but there are only two well-known ones, the *Bacillus enteritidis* and *Bacillus botulinus.*

It is a mistake to think that prime beef or mutton can in any part of this country be got at cheap bazaar rates. The best meats can only be obtained by careful stall feeding, and this costs money. The ordinary bazaar meat is, as a rule, simply grass fed, and in the hot weather, this feeding in scanty. The carcase of a bazaar sheep does not often go beyond 28 or 30 pounds, consisting largely of tendon and bone and without much flavour.

Pork.—Pork is the least wholesome of the flesh foods. It contains a large percentage of fat, and the fibres of the muscle are hard, close, and difficult to digest. A great deal depends on the age of the animal and on how it is fed and looked after. Fat pigs have about 50 per cent. of fat.

Curing of bacon and ham.—*Bacan and ham* are made by curing the flesh. The sides, legs and chaps of the pig are treated with a mixture of salt and saltpetre, and afterwards suspended in the smoke of burning oak (or other hard wood), or sawdust, for several days. When removed from the smoke-room the pieces are packed in a drying-room, and in about six weeks are ready for the market. Properly cured bacon is more nutritious than fresh pork, as it contains less water, and the curing renders the fat more digestible. The lean portions are, however, rendered hard and dry by keeping the meat in the pickle of salt and saltpetre, thus abstracting much of the nutritive juices.

Whether salted or cured, pork is an article specially useful for healthy people who work hard for their living in the open air. It requires a fairly strong digestion and should be eschewed by those leading a sedentary life, those who are weak, and people who have delicate stomachs. In the shape of ham or bacon, and in small quantities, it is a very useful article in the kitchen of Europeans in this country.

The pork of the Indian pig is to be avoided, unless it is from a properly kept and well regulated piggery, under strict supervision.

The indigenous animal reared in villages is unsafe as food. It is a foul feeder and sometimes suffers from "measles," which, like a similar disease in cattle, gives rise to a form of tape-worm in man. Salting or smoking, or both these processes, are insufficient to destroy the scolices* of bladder-worms. It is only by heating meat to a temperature of 170° F. for some time that these are killed. If the meat is found with these bladder-worms, it should be destroyed.

Neither Hindoos nor Mahomedans eat the flesh of the pig, and so the *Tænia solium* (the mature tape-worms which man gets from "measly" pork) is not met with in this country except in other castes and in Europeans.

Lard is prepared from pork fat. It is occasionally used in the kitchens of Europeans in making pies, pastry, etc.

It is difficult to detect decomposition in *sausages* until the actual smell of putrefaction appears. One method of early detection is that of mixing the sausage with an excess of water, boiling and adding fresh prepared lime water. Good sausages give a faint ammoniacal but not disagreeable smell; bad sausages give a very offensive, peculiar ammoniacal odour.

Eggs.—Egg consists of two chief parts, the white or albumen or nitrogenous part, and the yellow, or oily part. It is from the nitrogenous part that the young chicken gets the material for its flesh, bone, and blood, while the fatty part of the yolk supplies it with heat, and energy which enables it at length to break the shell, enter the world, and begin an independent life.

The egg of an ordinary indigenous fowl weighs anything between 1 to 1½ ounces; a duck's egg 1½ to 2 ounces, a turkey's from 2½ to 4 ounces, and a goose's egg from 3 to 5 ounces. Eggs form an important part of the diet of many classes. They are equal to lean meat in nutritive value as regards proteid material, but contain more fatty substance. They are best eaten half-boiled or poached; or made into an omelette. They should always be fresh. Stale eggs are far from agreeable, and may give rise to indigestion, diarrhœa, or other alimentary trouble.

The shell constitutes 10 per cent. of the weight, the white 60 per cent., and the yolk 30 per cent. The white consists of albumen and water, the yolk of fat, albumen and water. Eggs may be *preserved* by excluding air by means of a coating of lard, oil, gum, wax, etc., or by boiling for half a minute to coagulate the surface albumen. Eggs are also preserved by the use of antiseptics—soaking them in lime water, salt water, or a solution of boro-glycerid.

Good eggs sink and stale ones float in a solution consisting of two ounces of salt to a pint of water. Fresh eggs are transparent at the centre, stale ones at the top.

* The embryoes of the tape-worm alluded to on pp. 175, 176.

Fish.—The flesh of fish contains albumen, fibrin, and gelatine, as the muscular tissue of other animals does. It is less nutritive than the flesh of land animals. As a rule, it is rapidly digested, but contains less flesh-forming material than the flesh of birds and mammals. There is a great variety of fish, and this variety gives every shade of digestibility. As a rule, fresh fish in the natural state is very disgestible. There is a certain amount of mineral matter, especially phosphates in the flesh of fish. The two chief varieties are those with, and those without, fat. The latter are mainly eaten in India, and from the absence of natural fat it is necessary to make up for the deficiency by the addition of butter, ghee, fat, or oil, during the cooking process. Fish is always best for food when fresh; tough and dry fish is indigestible. The way in which fish is cooked greatly influences its digestibility. The best mode of preparing fish is simply to boil and use some butter as sauce with it. Fresh fish is decidedly better than salted, smoked or sun-dried fish.

In selecting fresh fish see that the gills are red and bright; that the flesh is elastic, firm and unyielding—does not "pit" on pressure with the finger—if after such pressure the flesh remains indented, the fish is stale. In decomposed fish held horizontally the tail droops, the skin has, a dull appearance and may show a play of colours, the flesh easily parts from the bone and leaves a brown mark, and it has a very offensive smell. The least decomposition renders fish unfit for food. Decomposed, putrid, tainted and stale fish may cause cholera-like symptoms and should always be condemned. Neither fresh fish nor shelled fish should be used out of season.

It is always necessary to be sure that fish is fresh. Ice-carried fish from long distances in the hot weather should always be considered suspicious, the safest rule when at all in doubt being to have it served up boiled or fried, in which condition either the odour or the first taste intimates whether any decomposition has set in. Such fish should never be eaten in the form of made dishes, as this tends to disguise the earliest stages of decomposition.

Fish is preserved by drying, salting, canning and curing. A great deal of salted or dried fish used is only half cured and is then eaten in a state of decomposition. This is accountable for an enormous amount of disease of the alimentary tract met with in India, and is also indirectly responsible for a vast proportion of the cases of dysentery and infective diarrhœa met with. Putrefying fish of this description sometimes causes death. Fish when theroughly salted, or properly cured, and completely cooked is not an unwholesome article of diet. Nevertheless dried or salted fish should be avoided by all who can afford to use fresh fish.

Crustaceans.—*Shrimps* (*chingari*) and *prawns* require careful selection; the smallest degree of decomposition in them may create the most acute intestinal irritation and diarrhœa stimulating cholera in its symptoms. For some unknown reason fresh and properly cooked prawns sometimes give rise to considerable irritation of the stomach and bowels.

Oysters.—Oysters obtained from sea-coast towns when not absolutely fresh may cause serious symptoms. Fish and oysters have both been accused of causing cholera at times in India; comma bacilli have been found in the intestinal canal of fish by Professor J. W. SIMPSON in this country. It is also considered that oysters may, in India, as in Europe, be responsible for some cases of typhoid fever.

C.—Milk and its products.

Each of the bodies entering into the composition of milk is so combined as to form, collectively, the most suitable food for infants. But milk alone is not adapted to the requirements of the healthy adult. To get enough solid nourishment from milk, an adult in moderate exercise would be obliged to drink six or eight pints a day. He would then be taking too much water, and an excess of some, and a deficiency of other, food-stuffs.

The bodies entering into the composition of milk are—*Casein* or curd (which, when acted on by rennet or some acid, forms the chief part of all kinds of cheese); *Cream* (from which butter and *ghee* are prepared); *Sugar of milk* or *lactose* (which gives the sweet taste to milk); *Mineral Salts, and Water*. We see that each class of food is here represented; they are in such proportion as to perfectly nourish the quickly-growing infant, the large amount of water helping the rapid chemical and constructive changes going on in its body.

Cow's milk.—The nature of milk depends largely upon the animal from which it is drawn. *Cow's milk* is one of the most important agents as an article of diet for the people of India. Cow's milk contains more casein and fat than human milk, but less sugar; therefore, when a mother is obliged to give cow's milk to the newly-born infant, she should mix it with a little more than half its quantity of water and add a little sugar, gradually decreasing the quantity of water added. *Buffalo milk* usually contains from 7 to 9 per cent. of fat. *Goat's milk* is richer in cream and poorer in casein than cow's milk, but does not contain so much sugar. Some people digest it better than they can cow's milk. Goats are not clean feeders, and if goat's milk is used the feeding should be seen to.

The average percentage composition of Indian cow and buffalo milk, deduced from a series of analyses, is as follows:—

	Cow.	*Buffalo.*
Proteids (Casein, etc.)	4·00	4·69
Fat (Butter)	3·90	8·38
Lactose (Sugar of milk)	4·02	5·12
Salts	0·73	0·75
Water	86·20	81·31
Specific gravity ...	1030·00	1033·30

These are average percentages. It is well-known that they vary within fairly wide limits when the analyses are made at different seasons, the milk being of much better quality in the cold weather.

Casein or curd is separated from milk in various ways, but chiefly by the addition of some ferment or acid. *Rennet* * is largely used in

* *Rennet* is an acid fluid got from the inner coat of the fourth stomach of the calf. In using it with milk the coagulated curd sinks to the bottom and carries down with it more or less of the cream and mineral salts of milk.

cheese-making countries, a small quantity of it being enough to make a large amount of cheese. Milk coagulates in all stomachs, but it is digested, and the curd thus formed is soft and loose, unless there is some disorder of the stomach that creates very acid gastric juice, in which case the curd forms large, indigestible lumps. *Cheese* is mainly composed of curd, entangling a certain amount of the milk fat, but it always contains some of the other constituents of milk. In proportion to the quantity of cream, is the quality of the cheese.

The sweet taste of milk is due to the lactose which it contains. Lactose has a great tendency to change into *lactic acid*, which makes the milk sour, and it is this change which usually causes spontaneous natural coagulation or curdling of milk.

The mineral matters contained in milk supply salts to the blood and help to build bone, etc.

Water forms the bulk of milk. It serves as a medium in which all the other constituents of milk are suspended or dissolved. When milk is coagulated by an acid, by rennet, by natural fermentation, or decomposition the *whey* is left. This consists chiefly of water with the sugar of milk, which is very fermentable, dissolved in it.

As milk is so important an article of diet in India, we should be prepared to form an idea as to the quality of any specimen. The quality of milk is influenced by the nature of the food and the condition of the health of the animal yielding it; if both these are good the milk should be wholesome.

Characters of good milk.—In estimating the quality of any particular specimen of milk, we have chiefly to rely on the *appearance and the taste of the milk together with the amount of cream.* Good milk is quite opaque, with a whitish or yellowish white colour; it is free from any peculiar smell or taste, and without any deposit. It should contain not less than 8 per cent. of its volume of cream, it should not alter its character on boiling, and its specific gravity should not be less than 1026—1028.

The ordinary purchasers of milk can estimate the amount of cream and the specific gravity, and from these form a good idea as to the quality of the milk.

Gowallahs adopt various means of adulterating milk, the chief of which are the removal of part of the cream and the addition of water. To detect these two forms of sophistication an instrument called a *lactometer* is issued in association with an estimate of the percentage of cream.

Lactometer.—The lactometer is a small glass instrument consisting of a bulb the bottom of which is weighted with mercury, and a tube, the tube being graduated. Different makers graduate the lactometer in different ways. One common way is to graduate the tube from 0 to 100, the 100 being placed near the bottom of the

stem and the 0 near the top. This instrument in pure water sinks to 0, in pure milk the stem would stand out above the liquid with the 100 in a line with the surface of the milk. If the stem sinks to the mark 80 it would indicate that in 100 parts there are 80 parts of pure milk and 20 parts of water; if it sinks to 50 it is half milk and half water, and so on. Sometimes the stem is marked with only the figures 1, 2, 3, 4, the 4 being at the top and the 1 near the bottom; the figured indicating that 1 part of water is added to 3 of milk, 2 showing that it is half milk and half water. We may also roughly estimate the quality of a sample of milk by means of any ordinary *specific gravity* * *bulb*, the stem of which is graduated. The specific gravity of *cow's milk* in this country varies from 1027 to 1032, the average being 1029; of *buffalo's milk* 1030 to 1035, the average being 1033. The higher averages are met with in the cold weather, and the lower during the hot weather. In the hot and dry season of the year, when all grass has dried up and fodder is expensive. the specific gravity of cow's milk may sink to 1027 without any adulteration with water, but pure buffalo milk rarely goes below 1030. Any milk with a specific gravity below 1027 has certainly been diluted.

Estimation of the percentage of cream.—When milk is allowed to stand the fatty part rises to the surface in a thick layer; this layer is the cream. To estimate the proportion present we put some of the fresh milk into a long glass, preferably a narrow one that is graduated from 0 to 100. Any elongated glass of uniform diameter will answer the purpose if we paste a strip of paper marked with 100 lines equidistant from each other on to the outer surface of the glass corresponding with its containing part. We allow the milk to stand for 12 hours in a cupboard away from currents of air. At the end of this time the cream will rest on the milk; the line of junction is easily seen and the percentage can be at once read off.

The proportion of cream in ordinary *cow's milk* varies from 7 to 12 per cent., the average being 8·5 per cent.; the percentage in *buffalo milk* varies from 9 to 15 or even 18 per cent., the average being 11·5. In the hot weather the milk of the ordinary *gowallah* may contain as little as 6·5 per cent. of cream without creaming or watering. The percentage of cream in cow's milk should not be below 6·5 in the hot weather and 8·5 in the cold weather.

If milk is deprived of its cream, it becomes specifically heavier, because the fat of the milk is lighter than water; when water is added without removing the cream the milk becomes specifically lighter. If, however, the cream is removed and water added the amount of added water may be so adjusted that the specific gravity remains the same as in ordinary milk. In this latter way a milk that is naturally rich in cream may have the excess of cream removed and water added and still be within the permissible limits as regards cream and other constituents.

Watering alone is detected by the lowered specific gravity of the milk and a decrease in the proportion of cream. *Creaming* alone is known by the heightened specific gravity of the milk and a lowered proportion of cream. When both watering and creaming are adopted the proportion of cream is reduced, but the specific gravity may be normal, unless an excess of water is added when the specific gravity will be low.

The bazaar *gowallah* is dirty in himself, his cows and buffaloes are dirty, their byres are mostly unspeakably dirty, and their food is often garbage and stable litter. In the hot weather when the supply of fodder is scanty the bazaar cow will eat any refuse, and in this respect is no more fastidious at this season than the bazaar pig.

The water used for adulterating the milk is often contaminated. The tricks of the *gowallah* in watering milk are unfathomable, and their acts of sleight of hand in this process beyond us. Lieutenant-Colonel G. M. Giles I.M.S., relates an instance in which the *gowallah*

* By *specific gravity* is meant the weight of an equal bulk of different substances compared with some standard for comparison. *Water* is taken as the standard, and for the purpose of comparing liquids of different specific gravities is said to have a specific gravity of 1000.

when about to draw milk always brought a bowl of clean water, by way of pandering to the *Sahib's* fad for cleanliness, with which he ostentatiously washed the udders of the cows and while milking, on the pretext that a cool hand was necessary for the process, he occasionally dipped his really well-washed hand into the bowl. Hidden in the palm, however, was a piece of sponge, which was squeezed against the udder in the action of milking, so that its contents mingled with the milk as it jetted into the can, and by frequently repeating the cooling process, he was able to dilute the milk to a very profitable extent.*

The use of the unsterilised milk from the bazaar *gowallah* can seldom be free from danger if we consider the feeding, the foul atmosphere and surroundings generally in which the cows and buffaloes live, the pollution with impure water before leaving the cow-shed, and other possible sources of contamination after leaving him and before it reaches the consumer.

Personally one has never seen a dairy under entire native supervision in which there were not many loopholes for the entrance of disease-germs into the milk supplied. This one states after being ten years a Health Officer in a large Municipality where one had to constantly watch the milk-supply.

There is an unreasonable prejudice entertained by many Europeans against the use of buffalo milk and butter, although it is twice as rich in butter as the milk of the ordinary humped cow of this country. There are few really good dairies that can conduct their business with a profit without the use of buffalo milk. The usual objection to buffalo butter is its white colour, but dairies overcome this by the use of many perfectly innocent colouring matters. Most of the indigenous tinned butter in the Indian market is obtained from buffalo milk.

A pure milk supply, that is, a supply of clean and unadulterated milk, requires that the milk be drawn from healthy cows (in the best dairies the cows are free from tuberculosis as shown by the *tuberculin test* †), living under healthy conditions, the milk is drawn by clean hands from clean udders into clean utensils, and protected from all forms of contamination and infection ; it is kept cool by refrigeration, and is never exposed to dust or any form of contamination from the time it leaves the cow until it reaches the consumer. Refrigeration is a special requirement in Indian dairies, as it has the effect of preventing changes in the milk, which it does to a large extent by devitalising bacteria that cause milk to ferment in various ways. The milk should be at once placed in the refrigerator. This, however, does not necessarily kill disease-germs in milk. The refrigerator should never be in the cow-shed. In most bazaar dairies the cows are not regularly cleaned, the foul atmosphere and surroundings generally in which the cows

* *Climate and Health in Warm Countries*, p. 51.

† Inoculation of milch cows suffering from tuberculosis with tuberculin (a vaccine prepared from dead cultures of the tubercle bacillus) causes a general lighting up of the symptoms including high fever, which render the disease obvious.

and buffaloes live, the adulterations of the milk with impure water before leaving the cow-shed, and other possible sources of contamination after leaving the cow-shed and before it reaches the consumer ; the hands of the milker are usually unclean, and the animals are poorly fed. The utensils are usually scoured out with earth and straw and finally washed with dirty water.

Milk to be wholesome must be got from healthy cows, which in grazing time should be permitted to roam in the open fields, if such are available, and in the non-grazing season, they should be fed on wholesome dried grass and allowed to exercise. *Gowallahs* in India frequently keep their cows and buffaloes confined day and night in yards that are in a highly repulsive state, the animals unkempt and unwashed, fed on the poorest food, often on stable litter, without fresh air and exercise. The milk under these circumstances must necessarily be more or less unwholesome. One has as Health Officer repeatedly been obliged to bring *gowallahs* before magistrates and have them punished for feeding milch cows on stable litter.

Fresh milk should never be put into dirty utensils ; they rapidly turn it sour. We know from experience that the feeding of infants and young children out of dirty bottles, cups, and saucers, is a frequent cause of diarrhœa, indigestion and inflammation of the stomach and small intestines. The same to a less extent may happen in adults using such milk. Milk rapidly turns sour in the hot weather ; insanitary surroundings and bad smells accentuate this. This may for a short time be prevented by the addition of five grains of bicarbonate of soda to the pint, and by boiling.

Milk forms one of the most excellent nutrient media for disease-germs. Hence it is the easiest article of food to infect, and such infection may arise in a score of ways.

Sterilisation of milk is effected by the use of heat at or above boiling point, or boiling under pressure. This is done at one heating to a temperature of from 212—250° F. lasting an hour or so, or it is heated to a lower temperature at regular intervals for several occasions. Both processes kill all germs in the milk, but they also alter its chemical composition to some extent. Special forms of milk sterilisers are obtainable at comparatively small cost.

Pasteurisation of milk.—Milk may be freed from all harmful germs at a lower temperature than that used in sterilisation, and this is done by *pasteurising it*. The temperature usually reached by the milk in pasteurisation is 158° F., which is kept up for ten minutes. This temperature kills all specific disease-germs, without altering the milk, and also the lactic acid bacillus which is the one ordinarily concerned in turning milk sour. This does not necessarily kill all germs in the milk, but it certainly kills all harmful ones.

Pasteurization of milk is adopted in a few dairies in this country. Special apparatus for this purpose, exceedingly simple to use either on a small or a large scale, are now purchasable.

Diseases caused by contaminated milk.—Cholera, typhoid fever, and dysentery, may be produced by specifically contaminated milk. All three diseases in such cases arise from either dilution with specifically polluted water, the use of unclean utensils, or exposure of the milk to the germs of these diseases. Milk has the power of attracting disease-germs, and once they gain access to it, they multiply rapidly. Specific infective germs may reach milk through flies.

In this country the chief disease communicated from milk *direct* from the cow is tuberculosis, especially when the udders are tuberculous. Tuberculosis may be produced in children fed on the milk of tuberculous cows *Gowallahs* suffering from tuberculosis, and expectorating on the ground in the dairy, is another source of milk contamination with the tubercle bacillus.

Milk epidemics.—Epidemic disease due to specific contamination of milk is shown by its suddenness, a number of people who have used the milk from a particular dairy or *gowallah* suffering at the same time—often two or more in the same barrack or household are attacked simultaneously ; and the barracks or houses taking more milk have more cases Milk-borne epidemics are as a rule mild, but they may form the starting point of severe epidemics in others who do not use the infected milk. The period of incubation of infective epidemic disease arising from milk is said to be shorter than the same diseases arising from infected water.

Malta fever * has been definitely proved to be due to the use of the milk of goats who are infected with a specific form of micrococcus which is contained in the blood, internal organs, and in the milk. A special commission that investigated the disease in Malta ascertained that 50 per cent. of the goats of that Island were infected with the disease, and that the milk of 10 por cent. contained the specific germ of the disease. It was also proved that monkeys and goats could be readily infected by feeding them on milk containing the specific micrococcus. Certain investigations carried out in India, especially in the Punjab, have shown that goat's milk was responsible for outbreaks of the disease in this country. The disease may be prevented with absolute certainty by the exclusion of goat's milk from any part of the food.

Milk is sometimes found to acquire dangerous qualities when kept and may then give rise to nausea, vomiting, dryness and constriction of the throat, burning sensation of the gullet, diarrhœa, cramps in the abdomen and legs, and collapse. This is due to a special chemical poison of non-bacterial origin called *lacto-toxin* or *tyro-toxicon*.

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* See article *Malta Fever*, PART IV.

Casein or curd of milk.—This is the chief albuminous or nitrogenous body contained in milk, and is that part from which *cheese* is made. The albuminous part of fresh milk is not coagulated into a mass by boiling as the white of an egg is, this is owing to the greater quantity of water with which it is combined.

Cheese.—*Whole milk cheese* is made from rich new milk. It has in it both the casein and the cream. Chedder, Cheshire, Gloucester and Gorgonzola cheese are of this kind. These belong to the best class of cheeses. Stilton is made from entire milk to which further cream is added. Sometimes cheese is made from milk that has been deprived of its cream ; the milk remaining is called *skimmed milk* and the cheese is called *skim milk cheese.* Dutch and Suffolk cheeses are of this class. *Cream cheese* is prepared from curds of the richest new milk to which additional cream is added.

A good cheese when kept under suitable conditions of temperature "ripens." In this process oxygen is absorbed and carbonic acid gas and ammonia are given off. The casein or curd undergoes a fatty change. This change is due to bacteria and their products, and many varietes of cheese are now made by artificially adding special bacilli which bring about these changes.

Cheese is a very nutritious article of diet. It is more nutritious than beef, as it possesses three times as much heat-forming material. In small quantities it assists the digestion of other foods. The rich old cheese prized by the *gourmet*, and thought to help the digestion of a rich dinner, is got rid of by the stomach with difficulty. Cheese, a few month's old, is more nutritious and digestible.

Tyre.—*Tyre* is milk boiled until much of the water is evaporated, then coagulated by the addition of some acid which solidifies the casein. It is a very popular accessory article of diet with all classes of natives in India.

Cream.—When milk is permitted to cool and stand in a vessel for some hours, it separates into two parts, the cream, which is the lighter, rises to the surface, and the liquid part of the milk remains below. When milk is heated the cream rises to the surface more rapidly. By skimming the cream from time to time, a very large amount of it may be thus removed ; such skimming materially lessens the nutritive value of milk.

When milk separates into its constituent parts, the fat first rises to the top, the casein goes to the bottom, leaving a clear fluid (*whey*) between the two.

Cream represents the fatty elements in milk. It consists chiefly of the fatty matter which forms butter ; it also contains a small quantity of casein, each globule of fat being surrounded by an envelope of casein. Cream is more easily digested than butter.

Ice-cream.—A number of epidemics of typhoid fever, and of severe diarrhœa have been traced to the use of ice-cream. The ice-cream may be infected by storage in infected premises. Ice-cream should be made on clean premises, never be kept in inhabited rooms, contamination should be rigidly prevented, and all ice-cream sellers should have their names on the ice-cream pails, or on some conspicuous part of the hand-cart they hawk the ice-cream about on.

Butter.—Butter exists in milk in the form of minute fat globules. Average butter has the following percentage composition :—Fat 82 to 86 per cent., casein 4 per cent., salts 0·5 per cent., water 8·5 to 13·5 per cent.

Butter on a small scale for messes or private families may easily be made by allowing the milk to stand in bowls covered with muslin, removing the cream, and afterwards shaking it in a wide-mouthed bottle, or whipping it up with a fork. Butter may also be abstracted rapidly from milk by using any one of the many household butter churns on the market which are clean, cheap, and of varying sizes so as to remove the butter from any quantity of milk from 1 to 16 pints. The processes named have the advantage that the butter got from bazaar milk in this way may be safely used if the milk is boiled first.

Ghee.—When butter is boiled and the fat which rises to the surface is decanted and called *ghee.* It is usually made by heating butter until a clear residue is left. The butter loses weight in this process; good *ghee* is more expensive than butter. Indeed, we might say that a large amount of material is sold in the bazaar which is not *pure ghee.* Pure *ghee* consists of almost entirely of fat. It is free from any bad smell, and keeps well ; it is easy of digestion, and is a very valuable addition to many kinds of food. Good *ghee* remains sound and free from rancidity for fully six months, but inferior *ghee*, especially if adulterated with water, soon becomes rancid. Ordinary butter contains about 84 per cent. of fat : *ghee* if pure contains 100 per cent. of fat. The *ghee* used for cooking Indian bazaar confectionery is often adulterated with cheaper oils.

D.—Vegetable Nitrogenous (Proteid or Albuminous) Food.

The food-stuffs included under this class are those which contain nitrogenous matter in the form of *legumen* or vegetable casein, which is always associated with much starch and salts. As examples we have the different varieties of legumenous foods in India. We have numerous species of *dals* and lentils, peas, beans and gram ; they contain a larger quantity of nitrogenous or flesh-forming matter than any of the other vegetable foods. Their richness in flesh-forming material renders them very valuable as foods in combination with fats or oil and starchy foods. Another special form of vegetable proteid material called *gluten* which is contained in some cereals, is dealt with later on.

Dals.—*Dals* form an important and valuable part of the food of the people of India. In consequence of the large proportion of nitrogenous (proteid) matter they contain, they are most useful in remedying the

deficiency of this proximate principle in the cereals used. They are largely used as staple articles of food, and are very nutritious. They are eaten with either rice or *chappaties*, being usually cooked into a kind of porridge or with vegetables.

Amongst the pulses or *dal* of India the chief are—Peo *dal*, *wihur dal*, *moong dal*, gram, *chena* or chicken pea, horse gram or *kulti*, fried pea or *desi matar*, European pea or *belayati matar*, Indian bean, *popal* or *shor*, soy bean, *bhat* or *guri kaldi*, *kesari dal* or *teura*, lentil or *mussoor dal*, *mothi* or *bhringi*.

Of these the chief ones used are—*wihur*, *moong*, *oorud*, *mussoor*, *matar* and *chena*. *Oorud* is the most usually employed; but *moong* is also a favourite and when properly cooked is a wholesome article of diet.

Kasari dal, which is cheap, may sometimes give rise to serious symptoms, including paralysis of the lower limbs, causing a disease called *lathyrism*.

"The pulses are prepared for food in various ways:—(1) The grain is soaked in water for several hours until it swells, or even without soaking it is husked and boiled with condiments and eaten generally as a curry along with the staple food; (2) it is ground, mixed with condiment and made into cakes or small balls, which are often fried in oil or *ghee*, and also eaten with staple food; (3) it is parched in the same way as rice and other grains, and then often used as food by labourers and travellers." (McNally.) *Dals* are somewhat difficult to cook and require to be steeped, boiled, or steamed for some hours before they are fit to be eaten, it is not until the grain, removed from the cooking-pot, can be easily crushed between the fingers, that they are sufficiently cooked.

The different *dals* when not thoroughly cooked may give rise to indigestion and diarrhœa; in the partially cooked state they are passed undigested in the fæces. Even when well cooked if used by persons not accustomed to them, they are only sparingly digested, and indigestion or other intestinal troubles may arise. The normal amount of *dal* eaten is 4 ounces a day, and 5 ounces is about the maximum that should be consumed.

Gram.—*Gram* is, as you know, largely cultivated in India. When young and green it forms a delicate "vegetable." When mature and dry, it is made into what is called *gram dal*, and can then be cooked in the same way as *mussoor* or *tur*, although it requires more prolonged action of heat to completely soften it. Parched gram is largely used by our Native soldiers on manœuvres and field service, and forms part of the emergency ration in some Native regiments.

Peas.—*Peas*, when young and green, contain a large amount of water, and but little nutritive substance, which is chiefly starch and

legumen. In the dried state mature peas are cooked in various ways, but under any circumstances they require the prolonged action of heat. They are somewhat difficult of digestion, although very nutritive, and tend to produce flatulency. They should never be used by people suffering from disease of the bowels.

Beans.—*Beans*, in the young and fresh state, as a food are much the same as peas; when ripe they are nutritive, containing a large amount of starch and nitrogenous matter. They are more wholesome than peas, and are well suited to correct the fat of animal food, hence they are frequently served up with it.

Fresh green peas and beans are easier to digest than when dried. If dried they should be thoroughly soaked and boiled before use, otherwise they are difficult to digest.

E.—Starches or Farinaceous Foods.

Starches or farinaceous foods are such as contain a considerable amount of *starch*. These are chiefly the different forms of cereal and leguminous grains, and starch roots. The most important are wheaten flour, rice, maize or Indian-corn, potatoes, arrowroot, and sago.

The food-grains used as staple articles belong to the natural order of grasses and are called *cereal grains*. The staple grain used by the people of each province is, as a rule, that which is most largely cultivated and cheapest. We are here, however, concerned only with wheaten flour and *atta*, and rice.

Wheat.—The different varieties of wheaten flour form the staple article of food of a large part of the people of India. It is a highly nutritive article of diet, is easily digested, and readily prepared either into bread or cakes. In composition it consists of 70 per cent. of starch, 11 per cent. of nitrogenous matter, and a small amount of salts and fat. The ease with which it may be converted into bread is due to a substance called *gluten*, which forms the chief part of the nitrogenous matter contained in flour. This gluten is to wheaten flour and to the flour of all cereals, what casein is to milk, or legumen to pulses.

Flour should be free from acidity and from a mouldy smell. The colour should be white. A yellow colour shows age, fermentation, or a change of starch to sugar. It should be free from lumps of grit. The microscopical examination of wheaten flour shows admixture with inferior flours, if these have been used to adulterate it, as practically the granules of all cereals have their own characteristic shape (Figs. 26—29, p. 172); the microscope also shows parasites such as fungi; the naked eye recognises weevils and flour mites.

Bread.—The facility with which ordinary flour and *atta* make a good dough is due to the cohesive properties of the large proportion of gluten which they contain. In making bread, the dough is charged with carbonic acid gas.

The carbonic acid gas is supplied to the dough in one of several ways—by means of yeast (" leaven ") or fermenting toddy, one or other of which is used in the *fermen'ed breads,* or by baking powders * (a mixture of alkaline carbonates, especially that of soda, and tartaric or other acid, etc.,), or by kneading the dough with water charged with carbonic acid gas under pressure—*aerated bread*—the latter processes being used in the non-fermented breads. In the process of baking bread, gas is given off by the fermentation of the yeast or toddy, or by the baking powder, etc., and the gas evolved permeates the dough forming numerous small cavities which give the bread its sponge-like appearance.

In good bread 100 pounds of weight by flour when cooked yield 130 pounds of bread. Bread should be made of pure wholesome flour, it should be well kneaded and raised, and not eaten fresh from the bakery—new bread is indigestible. The greatest attention should be given to the quality of bread consumed ; it is a daily article of food with our European troops. Bread serves to prevent us from taking too much animal food and it gives volume and proper consistence to the food.

There are three kinds of bread : *white*, made from the flour only, *wheaten bread*, made with flour mixed with the finer bran ; *household bread*, made with the whole substance of the wheat grain. The first of these is the ordinary bread made for troops in India. Fine white bread is more agreeable than the other kinds, but it is less nourishing ; on the other hand, coarse common bread is more nutritive.

Characters of good bread.—Good bread should be white. A yellow or dark colour may arise from the use of old or inferior flour, bad yeast, or the presence of bran. Acidity may arise from the use of old or inferior flour or sour toddy. Bread is sodden and heavy when from any cause the dough has not risen enough ; this most frequently arises from the use of bad yeast ; it may also be due to too much or too little heat or defects in the kneading process. There should not be more than 45 per cent. of water in bread. In bread the chief points to ascertain are—that it is free from alum and that impure or cheaper cereals have not been mixed with it. Bakers sometimes

* When good bread cannot be made from the absence of yeast, baking powder may be used for making bread. A fairly good baking powder may be made from cream of tartar and bicarbonate of soda, mixing these separately with the flour, a teaspoonful of the former and a saltspoonful of the latter to about $1\frac{1}{2}$ pounds of flour. Bicarbonate of soda, sometimes called *baking powder*, is an important constituent of some baking powders without the addition of any acid On beating the dough, the bicarbonate gives off carbonic acid gas which causes the dough to "rise."

mix alum and other substances to the dough, making bread to secure whiteness, which is popularly considered a good colour in bread. This practice is to be condemned.

Biscuits.—Plain *biscuits* are made from wheaten flour and water baked at a high temperature. In the majority of biscuits, butter, sugar, milk, eggs, and flavouring agents are added. Those known as *diet* or *digestive biscuits* contain bran. Biscuits require to be well cooked but not burnt. Ordinary biscuits should have a light yellow colour, float, and partially dissolve in water. They should yield a ringing sound when struck, and should readily soften in the mouth. There should be an absence of weevils. Plain biscuits are more nutritious than bread in the proportion of 5 to 3. Large bodies of troops and sailors have used biscuits as the staple starchy food for a few months, but after this period the men lose weight.

Biscuits differ from bread in not being spongy and in the small percentage of water they contain, usually less than 10 per cent., sometimes not even 5 per cent. of water being present.

Chappatties.—The cakes or chappatties made from the coarse wheaten flour called *atta*, are the chief staple food of a large proportion of the people of India. The *atta* is kneaded into dough with water, made into thin flat cakes, and baked on an iron pan at moderate heat. They are very nutritious, wholesome, and when well cooked and fresh not difficult of digestion. Frequently *ghee* or oil is added to these cakes.

Rice.—Rice forms the principal food of millions of the inhabitants of India. It contains about 85 parts of starch in 100 parts, and is easy of digestion. From the large quantities that have to be taken to supply enough nourishment to the body, it is usually eaten with stimulating condiments, such as chillies, pepper, etc., to assist its digestion. It can be combined in various ways for food. Rice contains very little fat; *ghee* or butter is therefore usually combined with it in some way.

Fresh or new rice is unwholesome and liable to give rise to diarrhœa or indigestion. Rice should be at least 9 to 12 months old. New rice is cooked in about 25 minutes and yields much of its starch to the water, forming a thick *conjee*; further, the remaining rice forms a pasty lump which does not set well, and does not keep well. When rice is over a year old, it takes about half an hour or so to cook and the *conjee* water is then thin; the rice sets well and keeps well.

Rice is better cooked by steaming than by boiling—most of the proteids and salts are dissolved out in the *conjee* water by boiling. In preparing rice from paddy or *dhan* it is well to remember that 8 parts of unhusked rice yield 5 parts of cleaned rice.

Much damaged rice finds its way to the market in India. This is chiefly due to its having got wet in transit in boats, or at some time betweon reaping and reaching the market. The result is that it partially ferments, or decomposes. Such rice should always be condemned, and inspectors of food should, during their rounds, be on the look-out for damaged rice exposed for sale or being used in the making of confectionery.

Certain changes occur in new rice which some authorities consider are concerned with the production of beri-beri. Those who habitually use cured rice suffer less from this disease than those who use uncured rice. Cured rice is rice that is boiled and dried before being stored and ground; uncured rice is stored unboiled and unhusked.

The sweetmeats and confectionery sold in bazaars are often prepared from unwholesome materials that cannot be sold in the raw state because of their obvious deterioration or impurity. Hence it is always wiser for Native troops to prepare such confectionery in their regimental kitchens from milk, butter or ghee, flour, sugar, etc., of known purity.

Effects of eating stale cooked cereal foods.—One of the commonest sources of intestinal and other derangements, and often of serious specific disease in Native soldiers, is the practice of eating food which has been cooked the previous night for the next day's food, or in the morning before work. This is usually done to save fuel or time. The food becomes decomposed, or absorbs disease-germs from insanitary premises; or sometimes the food, which is often of acid reaction, is kept in metallic cooking utensils, brass or copper, and the metal may add its quota of baneful substances.

The chief tubers and roots used are—potato, sweet potato and *taro*; the latter two are not included in ordinary rations.

Potatoes.—About 75 per cent. of potatoes consist of water, the remainder of starch with a small quantity of salts. Bulk for bulk, therefore, they are much less nutritive than other starchy food. Potatoes should be used with some nitrogenous food as meat, fish, eggs, etc. They should not form the chief part of a meal. They are best when boiled in their skins which keep in the nutritive matter.* In boiling they should not be allowed to soak for too long a time. Potatoes may be cooked by steaming, boiling, baking or frying. They require to be thoroughly masticated before swallowing. Half boiled potatoes are very indigestible, and a source of intestinal irritation. Properly cooked potatoes are very digestible and antiscorbutic. Good potatoes sink in a solution of salt having a specific gravity of 1,100; bad ones float.

Vegetable oils.—These are very largely used for cooking purposes by the people of this country. The chief oils employed are expressed from different seeds, etc., such as ground-nut, cocoa-nut, gingelly seed, *til* (sesamum), and mustard seed. These oils are wholesome and nutritive and serve a useful purpose in the food of many millions of people in India. The seeds producing edible oils when expressed yield varying percentages of oil. All oils when expressed in the cold state are purer than those expressed by heating processes.

All staple articles of food—wheaten flour, *atta*, rice, *dal*, potatoes, milk, butter, ghee and fresh meat of all kinds—issued to British and

* The potato contains a small proportion of gluten. This is situated just beneath the skin. When potatoes are peeled for cooking this gluten containing part is pared off. The best way to preserve this part is to cook potatoes in their skins.

Native troops should be systematically inspected by some British officer with technical knowledge before it is issued or sold. It has fallen to one's lot as Sanitary Officer to examine wheaten flour containing sand and weevils, *atta* that was almost half husk or in a state of partial fermentation from moisture; rice that was so broken up as to be uncookable, ghee that was rancid or mixed with cheap vegetable oils, etc.

The same remark holds good as regards field service. With our present Supply and Transport Department, its trained officers and organised methods of providing food for soldiers on field service, defects in the quality of the food-stuffs provided should seldom if ever be met with. The point one would emphasise is that it is always necessary that some one qualified British officer should be responsible that every bag of flour, atta, rice, *dal*, potatoes, etc., going to the front is of good quality, that every cow, sheep or goat slaughtered is fit for use as food, and that the accessory articles of the British and Native soldiers' diet are good and wholesome.

F.—VEGETABLES AND FRUITS.

Green vegetables form an important part of diet. Like fruits they furnish us with the salts and vegetable acids that are so necessary to keep the blood in a healthy condition. We have mentioned the potato as being a wholesome addition to our food. Other articles are equally good, such as cabbages, cauliflowers, onions, *brinjals*, various forms of sage, carrots, turnips, and beet-root. It is a wise rule never to eat uncooked food on field service, especially raw vegetables. The use of fermenting vegetable foods, especially stale rice and vegetables, and partially decomposed animal food, including fish of all kinds, should be strictly forbidden throughout the force.

Many vegetables are best eaten when young, such as ladies' fingers (*bhindi*); pumpkins, onions, and tomatoes will keep a fairly long time, even in the hot weather, when hung up in an open place and not in contact with each other. In this way they may be stored and thus tide over a period when vegetables are scarce.

All vegetables that cannot be properly peeled should be thoroughly cooked. Tomatoes should always be peeled before being eaten. This is best done by dipping them in boiling water for a moment. Cucumbers also should invariably be peeled, one half being dipped into boiling water and peeled and then the other half.

Cooking of vegetables.—A great deal of carelessness is seen to prevail in India in the *preparation of vegetables* for the table, especially when boiling is adopted, and when uncooked it is not uncommon to find slugs, worms, etc., in lettuce or other salad. All vegetables before being boiled should be thoroughly washed and cleaned. Every part of the vegetable must be searched for parasites. The object of cooking is to break the cellulose envelope of the vegetable cell. Therefore all vegetables should be boiled enough to effect this. Overboiling, however, is to be avoided, as it converts the vegetable into a pulpy mass, which is unsightly, insipid and flavourless. The colour, and usually the shape of the vegetables, is to be retained after boiling. In boiling vegetables, they are to be placed in boiling water, and a sufficiency of salt should be added to the water. The water should be kept boiling rapidly; no cover is to be on the saucepan; they are to be watched; when they sink in the water they are sufficiently cooked. Should the

vegetable be not quite fresh, a little carbonate of soda added to the water gives back their green colour. It is as well not to boil vegetables in hard water—if this must be done a little carbonate of soda facilitates the cooking.

Caution regarding the use of raw vegetables.—Raw vegetables, especially those used as salads—lettuce, beet-root, water-cress, etc., should be avoided unless thoroughly cleaned in water that has been boiled and allowed to cool. The dirty habits of some gardeners and vegetable sellers, the germ laden dust, the use of contaminated water for washing them, and other causes, make it imperatively necessary to either avoid their use, or to be certain that they are properly prepared; where personal supervision or that of some responsible person cannot be given to vegetables, they should not be eaten in the raw state. Amongst the parasites that may be ingested in this way are—the eggs of round-worms, and vegetable micro-organisms, especially the bacilli of dysentery, typhoid fever, and cholera.

When vegetables are scarce it is always worth while inquiring into the nature of the vegetables used by the local inhabitants; it will often be found that they use various excellent green vegetables and sometimes different beans. The leaves of many succulent plants are often used as spinach, and many herbs, both wild and cultivated, are used by the people of India and on our Frontiers that are good substitutes for vegetables, *e.g.*, the tops of the ordinary gram plant (*Cicer arientinum*) are quite good.

One might here incidentally mention that tinned compressed mixed vegetables and compressed potatoes are poor substitutes for fresh vegetables. They require much more cooking than can usually be given them, and, in a deficiently cooked state are a source of gastric and intestinal irritation, giving rise to colic, diarrhœa, etc., and paving the way to onsets of infective diarrhœa, dysentery and enteric fever. When fresh vegetables cannot be regularly obtained on field service, there should be a periodical issue of lime-juice to all troops and followers.

Fruits.—Except for the sugars they contain fruits possess comparatively little nutritive matter, but they are valuable and wholesome foods which should when possible form an important part of the daily dietary. The sugars in fruits are readily assimilated and used as heat producers. Fruits contain certain organic acids which are valuable for maintaining the quality of the blood. Acid fruits are unfit for food until cooked and sweetened with sugar. The sugar should be added after the fruit is cooked, otherwise the acids in the fruit alter the sugar and cause it to lose its sweetening properties.

Fruits, when preserved, should be placed in bottles and not in tins, as the acid of the fruit is liable to act on the tin and solder, give the fruit a decidedly metallic taste, and may cause lead colic, gastric, or intestinal disturbance. This solution of the tin can be prevented by coating the tin with a fairly thick layer of shellac. Nevertheless it is preferable to preserve fruit in bottles.

Lime-juice makes an excellent beverage in the hot weather besides being a very good antiscorbutic.

All fruit that cannot be properly peeled should be cooked. All sound fruit, that is, neither unripe nor over-ripe, may as a rule be taken with advantage by most people. Apples in the hot weather are rather difficult of digestion as are also the harder parts of melons. The latter are often grown in unsavoury soils, and it is always a safe rule to put them for a few moments in boiling water before use.

G.—Preserved Animal Foods.

Preservation of meat.—Meat is preserved in one of many ways :—

1. *By exclusion of air.*—The meat is dipped into boiling water, to coagulate the albumen on the surface. This process in India only delays decomposition a short time.

2. *By application of preservatives to the surface.*—The meat may be covered with salt, sugar, boracic acid, boroglyceride, powdered charcoal, or even solutions of antiseptics. This does not delay decomposition indefinitely.

3. *By pickling.*—Common salt with a little saltpetre is rubbed into the meat or the meat is kept in strong brine. Water is abstracted and the salt acts as a preservative. When only partially preserved by salting, meat may give rise to very serious symptoms like cholera.

4. *By drying.*—The meat is exposed in thin slices to dry air, or to the smoke of a wood fire, or in the sun.

5. *By canning or preserving in tins.*—In tins or other containers meat is hermetically sealed *in vacuo* or sterilised air. The air may be abstracted from the tin before sealing, and replaced by nitrogen and sulphurous acid, or by air which has been heated to 500° Fahr., or by steam. Other processes aim at the complete exclusion of air, or exclusion of part of the air, and removal of oxygen from the remainder by means of sodium sulphite ; or at the exclusion of all germ life by boiling.

Meat is generally preserved by cooking and canning in sterilised tins. One has seen this process as carried out in over a dozen large factories in North and South America, Australia, New Zealand and other parts of the world ; in every instance the whole process was conducted in the most sanitary and hygienic way ; the impression left on one was that in a large number of instances micro-organisms giving rise to meat poisoning gain access subsequent to the cans or tins leaving the factories.

In examining tinned provisions if there is a slight suspicion of a hollow or tympanitic note on tapping the tin,* a suspicion insufficient to justify condemnation, set the tin aside in a warm place for, say, 24 hours, and test by tapping once more ; if gas production is progressive the hollow sound will be intensified. When there is a drum-like note on tapping the tin, it is at least suspicious that some gas-forming process is going on. A convenient practical way of testing the presence of gas in a tin, is to place a drop of water at one end and

* Those employed in inspecting tinned provisions use a small wooden mallet to tap the tins with.

perforate the tin through the drop. If, as should be the case, there is a potential vacuum in the tin, the water will be sucked in with a hissing sound, if gas has been formed it will bubble through and create a froth at the position of the drop. As a rule if any part of a tin bulges it should be rejected. A properly exhausted tin that has been well sealed is either flat or slightly concave at the top and bottom.

Tins containing preserved food-stuffs, meat, etc., "are considered unfit when:—(1) Peforated by nails; (2) there are any angular indentations which are likely to have caused partial fracture of the tin or render it liable to rust; (3), they contain deleterious gas, or are bulged or blown; (4) they are rusty; (5) it is found that the tin has not been hermetically sealed, so that the meat has either dried or putrified in consequence."*

Tinned meat occasionally causes within 12 hours symptoms of acute irritation of the stomach and bowels, such as vomiting, purging, cramps, fever, weak pulse and great prostration. These symptoms may arise from decomposition, the result of imperfect canning of the meat; in this case the tin will be "blown," the meat may be offensive to both smell and taste. Sometimes no such changes in the meat are observed, and then the irritation may be due to salts, often zinc or lead, which are found in the meat of jelly due to the action of salt and organic acids on the tin or solder, possibly aided by galvanic action.

Europeans have occasionally to live largely on tinned foods and it is absolutely necessary for safety to health that when used such goods should be sound. Tinned foods should never be purchased except from the most reliable firms. It is necessary to insist on the careful examination of all tinned meats before they are consumed.

The consumption of tinned foods is so extensive, both in peace and war in the Army, that their mode of preparation is of much interest and importance to all medical officers of the services. An enormous quantity of tinned meat was condemned as unfit for food during the South African War, but it is certain that the greater part of this condemned meat became unfit for food owing to the tins having been damaged by rough usage and exposure, and that the meat itself had been of good quality when put up in the tins; and it may be said, from all the evidence recently accumulated, that meats tinned in the United Kingdom are of good quality. Nevertheless we must safeguard our troops against possible disease transmission (as of tubercle, or of animal parasites), and possible food poisoning (through ptomaines or toxins), and in the light of recent disclosures, all authorities concerned should exercise the most rigid vigilance in regard to tinned meats arriving in this country. It is desirable that in all cases the manufacturer's name, place, and date of canning, should be impressed on the can; and imported canned foods should be furnished with a certificate to the effect that they have been produced and prepared under proper administrative control and inspection.

* Notter and Firth, *Theory and Practice of Hygiene*, 3rd Edition, p. 333.

Most reliable firms now affix the date to their cans, and this date should always be looked for.

There is a form of localised bulging of tins called "non-bacterial blowing" which may not be due to decomposition ; this is said to be due to insufficiency of the tin lining, the acid of the food material acting electrolytically on the iron case and producing gas, which consists partly of hydrogen, partly of atmospheric air. The same action sometimes occurs in tinned milk.

Meat and fish that have been highly smoked or salted, and fish in oil are generally fairly safe, but fresh meat and fish in tins are articles that should be indulged in as seldom as possible. Tinned soups are usually quite safe and are decidedly better than meat extracts, which are, as a rule, stimulants with little nutritive matter.

A number of agents are added to tinned and preserved foods, sometimes in injurious quantities. It is not often that any serious effect arises from the consumption of such foods, but the general principle holds good, that at the present day the use of preservatives in canned food is unnecessary and should not be legally permitted. The chief agent added to meat foods at present is boric acid, which is used instead of the saltpetre of former days. Large quantities of such food as hams, sides of bacon, etc., are packed in boric acid, and potted meats prepared from these may contain as much as 17½ grains ("even up to 163 grains") to the pound, without having been added by the manufacturer.

Tinned meat or tinned fish if not properly preserved and canned may, when eaten, give rise to ptomaine poisoning characterised by vomiting and purging, fever, delirium, frequent and weak pulse, restlessness, and great prostration. Ptomaine poisoning may follow the use of decomposing food, and it is specially liable to occur after eating meats that have been preserved in badly sealed tins, or tins that have been perforated in any way. The ptomaines formed by the micro-organisms of decomposition in animal flesh are not destroyed by cooking, and with these are often microbes which have not been destroyed by cooking.

Salted or preserved meat, bacon excepted, has less nutritive value weight for weight than fresh meat. Hence the constant employment of salted or preserved meat should be avoided, fresh meat being issued as often as possible. *F. S. P. B.*, 1907, p. 43 and *Allowance Regulations* Section 2, lays down the equivalents of salted, preserved, and fresh meats.

Concentrated foods.—The chief principle in operation in the manufacture of concentrated foods is that of driving off the water of the natural substances from which they are made. These substances are mainly meat, milk, pulses and cereals. There are definite physical limitations beyond which concentration of food-stuffs cannot be carried. Take the case of meat. On an average, meat contains from about 15 to 20 per cent. of proteid material and from 60 to 75 per cent. of water, the rest being fat and salts or mineral matter. Hence the greatest degree of concentration possible is that of reducing meat from ¼ to ⅕ its bulk.

There is much misunderstanding abroad regarding concentrated foods in general. The actual bulk of foods can only be reduced to a certain extent. It is impossible to condense food in such a way that a week's supply can be carried in a few small tablets in the coat pocket. This applies to the concentration of all classes of food. The most condensed form of animal proteid is dried and compressed meat powder, and the pure casein of milk; of carbohydrate food, pure cane sugar, which, containing no water, its bulk cannot be reduced. Vegetable oils, and butter or ghee, when pure, are the most concentrated forms of hydrocarbons. For sedentary work the daily food of an adult man cannot be reduced to a less bulk than 12 to 14 ounces of solid material without the man losing weight; for ordinary moderate work 16 to 18 ounces, and for hard work 20 to 25 ounces. These amounts are for solid, dry, water-free food-stuffs, and they must consist of the proper proportions of the different proximate principles required in a diet.

Pemmican.—This is one of the best known concentrated foods, consisting of desiccated meat powder 5 parts, impregnated with fat 4 parts, and it is probably the most highly concentrated real food in existence.

Mixed prepared foods.—There are a vast number of these on the market which vary in composition from being quite simple, as in the case of Tropon, to such highly complex combinations as in some of the Army rations.

Tropon is a proteid food obtained from both animal and vegetable sources, being made chiefly from fish and cheap vegetables; ¾ of an ounce of it contains as much proteid as 4 ounces of raw beef. It is nutritive, and one of the cheapest concentrated mixed foods.

Erbswurst.—The original Erbswurst of the Germans consisted of simple sausage of peas with bacon fat. A large number of the foods on the market imitating this consist of powdered peas with bacon or beef fat, with various condiments, this combination being cased in some form of waterproof cover and sold as a sausage or packet. Various kinds of peasoup tablets belong to this class.

Army rations.—Various Army rations are on the market; "they consist of mixtures of either beef or mutton, with potatoes, onions, beans, gravy and pickles. Some also contain bacon fat and brawn, the whole being cooked and contained in hermetically sealed tins of small size, and may be eaten cold or warmed up. Maconachie's patent Army ration consists of ¾lb. of meat and ½lb. vegetables, and gravy, put up in a tin, the gross weight being 1lb. 13 ounces." Amongst the mixed fatty and carbohydrate concentrated foods we may mention *Virol* and *Virvis*.

When food acts as a carrier of infection it does so in one of several ways. The germs of disease may either be contained in the food itself (in partially decomposing meat, as embryos of tape-worm, etc.), or they may be deposited upon the surface of foods such as meats, milk, salads, rice, vegetables, either by man in handling, or by insects such as flies. After microbes are deposited on food, if the latter is a favourable medium for their growth, the germs may multiply within it, or upon the surface, and their virulence may be enhanced by their cultivation. Disease-germs may also gain access to prepared food through water used in mixing or diluting the ingredients. Milk, soup, gelatine foods, etc., are specially excellent cultivating media for germs, and should consequently be handled and protected with the greatest care. Oysters are particularly dangerous in India unless obtained fresh from reliable and known sources; they are both ptomaine producers and bacteria carriers.

H.—Cooking of Food.

Effects of cooking food.—Cooking renders all food more pleasant to the eye, more palatable and more digestible. Meat in its natural condition is fairly tough; by cooking the fibres are softened, and it is more easily broken up by the teeth, and the albumen is coagulated. Cooking breaks up the cellulose envelope of starch granules, which renders them easy to be acted on by the saliva and pancreatic juice. It should be remembered that ordinary cooking does not afford complete protection in meat that is infected with specific disease virus.

Cooking of meat.—The *cooking of meat* is necessary to destroy any noxious microbes or poisonous bodies that may be present in raw meat, to preserve it from putrefactive changes by heat sterilisation, to increase its digestibility, and to produce that palatability which a civilised taste calls for. In all cooking processes meat loses weight, usually from 20 to 30 per cent.

Boiling.—In boiling a joint the meat should be plunged into boiling water for 5 minutes to coagulate the outside albumen and retain its salts, extractives, and soluble substances, in the interior. The remainder of the boiling should be conducted at a temperature below 170° Fahr., which is the temperature at which most albumens coagulate, in order that the meat may not become tough, dry, and indigestible. On the other hand, in making soup or broth the meat should be cut into small pieces and placed in cold water, which is gradually warmed to 150° Fahr. In this way the salts and extractive matters pass out of the meat into the soup, together with a certain proportion of the more soluble albuminates. A final heating to a boiling temperature is advisable, if there is any suspicion of taint in the stock meat, in order that putrefactive organisms may be destroyed.

Stewing.—This is the most economical way of cooking meat, as nothing of the meat is lost; a large part of the nutritive material of the meat passes into the gravy. The meat with the ingredients to be used for flavouring (salt, pepper, onions, etc.) is put into the pot containing cold water and heated very gradually until the water is just short of simmering (160° to 170° F.), and kept at this heat for 3 or 4 hours. The pot must be kept completely covered and never allowed to really boil. Stewed meat is very digestible.

Baking and roasting.—*In baking and roasting*, the joint of meat should first be subjected to an intense heat to coagulate the outside albumen and retain the soluble juices; after a few minutes the temperature should be lowered and the roasting or baking completed at 180° F. to 200° F. The usual rule is to allow a quarter of an hour for every pound of meat in a joint over five pounds in weight. Aromatic and savoury products are formed in roasting and baking which are volatilised; some of the fat is melted and flows out of the joint together with gelatine and extractives to form the gravy.

All food of troops should be thoroughly cooked. Many men like to see the red juice flow from their cooked (*sic*) meat. Such meat, however, has not reached the point of cooking at which all germs are killed. When this latter is reached the juice is not red but brownish.

Responsibility of medical officers regarding food of the soldier.—The medical officer, with his special training, should be an expert in connection with all questions relative to the soldier's food in peace and war. On field service especially, medical officers of units, senior medical officers, principal medical officers of brigades and divisions, and sanitary officers of divisions, have their personal responsibilities in the matter of the soldier's diet; and the points alluded to, and others not included here, should receive their attention. One knows from experience that whenever any avoidable defects are pointed out to officers commanding regiments, supply officers, etc., such defects are when possible rectified immediately. These officers want such advice, and they look to responsible medical officers for it.

The cooking of the food should be specially attended to, particularly when fighting under high pressure. The medical officer attached to units will insist on this and all officers in the regiment should co-operate with him in the matter. With Native troops, he will emphasise the necessity of properly boiling the rice and *dal* (which he should frequently examine between his fingers in the cooked state) and see that the chapatties are properly baked, and not eaten in a doughy or half-raw state. In the case of European troops he will inspect the bread, the cooked meat, and vegetables, and see that no part of the latter escape proper preparation. Wheaten flour must be used for bread. *Atta* is undesirable either as bread or chappatties for European troops who are unaccustomed to it and under its use would soon suffer from diarrhœa, indigestion and general lowering of the system. Complaints are frequently made about the bread, and in most cases one has found these justifiable. It is rare to find any defect in the wheaten flour itself—the fault is usually in the kneading, the yeast, or other agent used for "raising," or in the baking. When men come in from a long march or after a hard day's fighting, and have but few hours to sleep before they are required again, they are disposed to give little attention to the preparation of their food, which under this circumstance is sometimes eaten half-cooked. This, apart from robbing the food of some of its nutritive value, tends to lay the foundation of various intestinal maladies—this is one of the factors which prepare the bowel for the multiplication of the enteric bacillus, of the different species of the dysentery bacillus, and of infective diarrhœa, met with in long campaigns on our Indian Frontiers and in the East generally. The cells covering the healthy mucous membrane of the alimentary tract are powerful antagonists to the attacks of disease-germs, but when those cells are themselves weakened by constant irritation from improper food or defective cooking, and their resisting powers

are reduced to a minimum, then such germs, which are probably more or less constantly present, get the upper hand and commence their work of invading the mucous membrane and deeper parts, or help other disease-germs which have gained access to do so. Each Japanese soldier during the Manchurian campaign received a tin-foil box containing 90 creasote pills, of which he was directed to take two daily as a prophylactic against typhoid fever, dysentery, and disturbances of the alimentary tract generally.

When possible, the same care should be taken in the cooking and preparation of food on field service, as in peace times. It should always be wholesome and appetising—tasteless food, lacking in variety, leads to a loss of appetite with its inevitable results. The soldier should be taught to cook his own food and to make it palatable from the materials he will have at his disposal on field service.

Several witnesses gave the Royal Commission on the South African War harrowing accounts of the sufferings of the men from bad food. A keen sense of these evils has moved the authorities of the United States' Army to determine that cooking shall be systematically taught in the Army. It is held that every soldier should be able to cook, and to that end military cookery schools have been established in Washington barracks and at some of the forts on the western side of North America. The same is done at Aldershot now by ourselves.

Doolies, with fly-proof wire-gauze panels all round, should be used to store and protect food from dust and flies. A liberal supply of wire-gauze dish covers should be in every officers' mess. All food-safes and wire-gauze covers should be thoroughly scrubbed with soap and water frequently. All utensils used for holding food, or cooking it, should be thoroughly clean, and well scalded and cleaned after being used at each meal.

Inspection of cooking utensils.—The cooking utensils in the kitchens should be repeatedly inspected to see that they are kept properly clean. Whenever possible, especially amongst European troops, the use of copper vessels should be avoided. In former Indian campaigns, and before the present camp kettles were introduced, obscure bowel complaints were attributable to acute or chronic copper poisoning. Copper and brass utensils in the Native Army should also be done away with. They involve much labour in keeping them clean, and, when used in a soiled state, may lead to bowel affections. Efforts are now being made in units to introduce aluminium cooking-pots, and one has every confidence that the innovation will more than repay the expense by increased numbers of efficient men. In cooking rice and vegetables in these aluminium utensils it is necessary to coat them outside with earth to avoid burning the food being cooked. In the United State Army and several Armies on the Continent of Europe, aluminium is largely taking the place of other metals for cooking and

feeding. When the man has to carry his feeding vessels, the difference in weight in aluminium is not a negligible factor.

The cooking utensils of our British troops consist of oval camp kettles in sets of 3, with 4 sets per company; these are packed in suleetahs. Each kettle is supplied with a gridiron, one chopper, and a ladle.

Hot food at end of a march.—All experienced officers recognise it to be very desirable that men should have some hot food at the end of the march. Waiting for baggage to arrive and meals to be cooked, whilst the body is soaked with perspiration and in a state of physical depression, is very liable to lead to chill, attacks of fever, bowel complaints, etc. A pint of hot strong soup, cocoa, or tea and a biscuit on arrival in camp or bivouac after a march, is very refreshing and cheering, and then the men can wait for the next meal without impatience; the feeling of fatigue, lassitude, and depression after a long march, rapidly pass off, and give place to contentment and a readiness to take things as they arise.

Many ways have been proposed to supply hot food at the end of a march to the men, such as providing a travelling cart with boiling water, with which and soup tablets the man can make his own soup in a few minutes, every man carrying his own soup tablets and a few biscuits, etc.; or with a self-cooking apparatus like the "Calorogen ration."

Hot meal before an attack whenever possible.—When an attack is expected the men should, whenever possible, have their breakfast or other meal, before the attack begins. "It is very important that the troops should be supplied with food regularly, and always before marching. In the event of an early morning march, or of men employed late at night, an extra ration of tea with a little bread o biscuit might be recommended."

Improvised kitchens.—When the cooking is to be done for a large party of British troops, the best way is to dig or build up a long trench for the fire, place the kettles on it (its width not being sufficient to allow them to drop into it), and cover up between them with stones and clay, so that the fire fed from the windward end may draw right through. A chimney can be built at the other end to increase the draught. A chimney can be built of sods and is supported where it passes over the trenches by flat stones, slates, wood covered with clay, etc. The inside of the trenches and of the chimney may be plastered with clay, which makes them last longer. Several such trenches may be combined to form what is known as the parallel or rectangular kitchen, or three trenches may converge to one flue, forming what is known as the "broad arrow kitchen". The Aldershot pattern or gridiron kitchen is depicted in *Manual of Military Engineering*, 1905, Plate 58, and Plate 57, figs. 4 and 5 of the same *Manual* gives details of a covered kitchen suitable for standing camps. The roof of this kitchen may be covered with tarpaulins.

For a party over 20, the simplest way, when only one day has to be spent in a camp, is to place a proportion of the kettles on the ground in two parallel rows about 9 inches apart, handles outwards, and block the leeward end of the trench so formed with another kettle; lay the fire and place over it one or two rows of kettles resting on those already in position*. Each kettle takes up

* *Manual of Military Engineering*, 1905, p. 68.

one foot of linear space, and can cook 16 dinners without vegetables, and 8 with vegetables. Mess tins can be arranged similarly, but in that case not more than 8 should be used together (*vide* Plate 59, *Manual of Military Engineering*, 1905).

Field Ovens.—The simplest form of field oven consists of a hearth sunk below the ground surface with an arch formed by a hurdle or sheet iron. The gable ends are formed with sods. The whole of the interior of the oven is well plastered with cow-dung and clay. The hurdle, well plastered on the outside with cow-dung and clay, so as to leave an arch when it burns away, is covered with earth from the excavation. The entrance to the oven is closed either by a hurdle plastered with clay, or simply by sods. This oven is well devised for making bread and will bake for 150 men at a time (*vide Manual of Military Engineering*, 1905, Plate 60. The service oven Aldershot pattern (Plate 58, fig. 2) should be fixed up without the flue, but placed on a prepared flattened site.*

Cooking arrangements for Native Army.—The cooking arrangements for our Native Army can scarcely be improved upon—they are simple, moderately quick, conducted without any great amount of nuisance and in many ways satisfactory, and with the exception of the necessity of some sort of absorption pit or receptacle for kitchen slops and the washing of cooking and feeding utensils, call for no comment. The use of slop pits is an important question with the Native Army, as the cooking and feeding utensils are washed after each meal, and this has to be done fairly adjacent to the kitchen. Those used during the Delhi and Rawalpindi manœuvres and at the Agra Concentration were about 4′ long 3′ wide and $3\frac{1}{2}$′ deep, the excavated earth being banked up on one side, and thrown in from time to time so that they were literally absorption pits. The kitchen ashes were also frequently deposited in these pits, the refuse charcoal of the ashes acting as deodorants, and doing much to keep them sweet— See *Sanitation of Camps*.

Meat-carts.—When an unusually large force is engaged, special arrangements have to be made regarding supplies for European troops. For these supplies special provision may have to be made in the shape of meat-carts, which permit cooking to be commenced at once when the march is finished.

Travelling kitchens.—The use of travelling kitchens was found to be of great importance by the Russians in Manchuria. There were two types in use—(1) in which the hermetically sealed meat-pots contained but little water, and the food was cooked by the steam produced. The kitchen was usually constructed to provide for a large meat-pot to cook the meat and vegetables, and then held another smaller one to cook groats; (2) a pot in which the food was cooked by the boiling water. Of each of these two kinds there were two sizes—(1) to cook for a company of infantry of 220 to 250, the other for a squadron of cavalry of from 150 to 170 strong. Of these, two types of each were in use (1) a four-wheeled apparatus for infantry, (2) a two-wheeled for cavalry; the kitchens could cook the meals either at the halt or when actually on the march: the meat-pot was enclosed in a case consisting of some bad heat conductor; each kitchen carried only one meat-pot; the pot was so constructed that it could be conveniently carried on one pack animal; wood fuel was exclusively used; the actual capacity of each pot was $67\frac{1}{8}$ gallons for the infantry, and $37\frac{1}{2}$ for the cavalry kitchen; the cart when loaded weighed not more than 20 cwt. for infantry, and about $13\frac{1}{3}$ cwt. for cavalry. The kitchen appurtenances—provisions, fuel, food for horses, etc., did not weigh more than 10 cwt. for infantry and $7\frac{1}{8}$ cwt for the cavalry kitchen, the weight of the empty cart being 10 cwt. for infantry and 6 cwt. for cavalry; for the infantry cart there were two boxes and for the cavalry one box to carry provisions, firewood, etc.; in both patterns the cart was two-horsed, the cavalry one being tandem.

* *Manual of Military Engineering*, 1905, p. 69.

On actual fighting days the hot food was carried up to the position at mid-day. There is a consensus of opinion that the kitchen carts were of vast use to the Russians in the late war. The four-wheeled carts were considered too heavy in mountainous country and heavy roads. When the roads were really muddy it needed six horses per cart, and large fatigue parties had often to be engaged for this. The limber consisted of a box where driver and cook sat, the box contained bread, dry provisions, salt, tinned food, etc., with a rack at the back in which various food-stuffs could be placed. In the rear waggon only a boiler was placed. The two-wheeled type of kitchen which can be drawn by one horse are now considered preferable. The two-wheeled cart, or some modification of it, would appear to be more suitable to Indian Frontier Warfare.

"The kitchen waggons allowed the men in the most advanced position to be provided with hot meals twice a day, a very good aid towards enduring the hardships of the weather. In the last position on the Sha-ho, the supply of food was carried out under cover of darkness, before daybreak, and in the evening. The kitchen carts were led up as close as practicable to the advanced line of entrenchments and halted under cover; the food was carried in small camp kettles up to the trenches, or the men themselves were sent forth to fetch it from the carts by units."

When on the march the meat was cooked for 2½ hours and then removed to a partition, where it could be kept warm for some time, while the bones were left in a little longer to improve the soup. On reaching the end of the march or during a long halt or temporary intervals in fighting, each man got his food. During winter hot water urns holding 3 to 4 gallons each, two per pack animal, were introduced, and were very popular both for making tea and hot water to warm food with.

Value of travelling kitchens on field service.—Regarding the use of these carts, before the late war, it had been said:—"The untiring endurance of the troops must be justly ascribed in a very great degree to the travelling kitchens, which raise the strength of the troops 20 to 30 *per cent.*, a fact clearly shown in forced marches, where the soldier eats his midday meal half-way at the halt, and his evening meal at the final halt at the end of the march. It may be safely asserted without exaggeration that three regiments with travelling kitchens are worth a whole division without them."

The manner in which these cooking carts of the Russians carried out their purpose was surprising, and it is said that at the beginning of the campaign, when all regiments were not provided with them, there was a decided difference as regards efficiency in those that were.

The Japanese likewise used a form of light stove-ovens which could be taken to bits, one per company, weighing 3½ cwt. with cooking-pots, etc., carried on pack animals, ten per battalion. Each battery and squadron of cavalry had two loads of cooking utensils. The disadvantage was that food in large pots of 115 gallons capacity had less savour than when each man cooked his own food; these could not, of course, cook food while actually on the march. In 40 minutes the rice rations of 75 men could be cooked in one of these ovens. Two kitchen carts were used by the Japanese for the Hospital Corps, who had little time to cook.

The great disadvantage of these cooking kitchens is the enormous increase in the transport required, but from the experience of the Russians, in their late campaign, it would seem that some such arrangement must inevitably be made in a large war with a powerful enemy provided with up-to-date armament.

I.—Sketch of Digestive Organs and Processes of Digestion.

The disgestive tract.—When we swallow food, it passes from the back part of the mouth into a pipe which begins at the top of the throat, and goes all through the trunk of the body. This pipe is called

the food canal, *alimentary* or *digestive tract*. From the mouth it passes into the sac-like cavity of the throat, called the *pharynx*, from which it enters the gullet, *œsophagus*, or "food-pipe." Below the gullet, the food canal widens out to form a sort of bag or resting place for the food, called the *stomach*. The walls of the stomach contain a large number of small blood vessels, into which the completely dissolved parts of the food passes.

Small intestine.—At the far end of the stomach, the pipe again lessens in size and passes onwards; this part is called the *small intestine*. In this division more food passes into the blood vessels through the walls, and in it also there are other little tubes into which another portion of the food enters, called *lacteals*, so called because the fluid they contain is like milk. From these lacteals it passes by a roundabout process to the blood vessels.

Pancreas or sweet-bread.—Into the upper part of the small intestines open the ducts which convey the digestive fluids secreted by the liver and sweet-bread or *pancreas*. The *pancreas* is a long flat glandular organ, situated in the abdominal cavity, somewhat resembling a dog's tongue in shape.

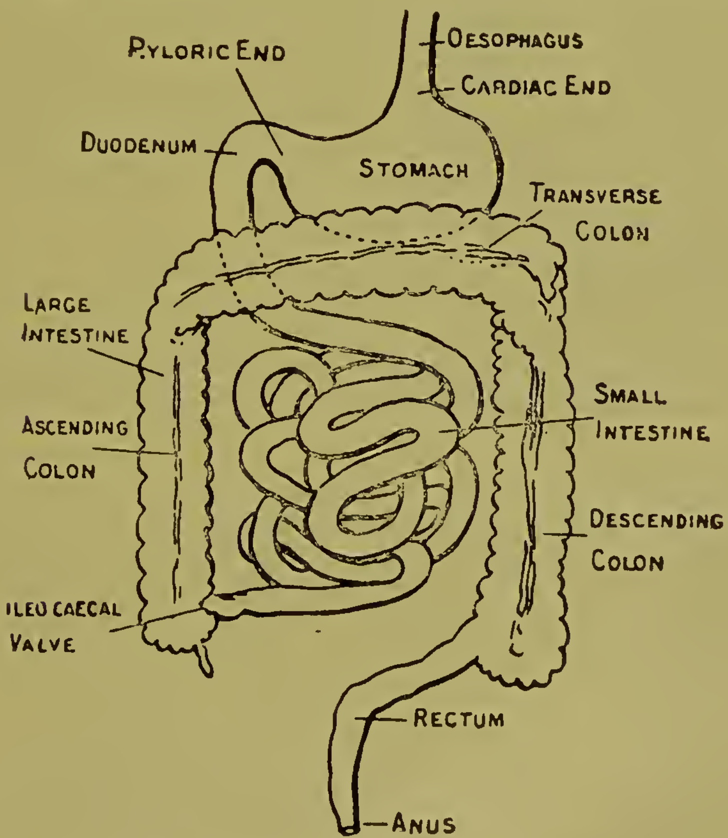

Fig. 33.—Diagram of stomach and intestine

Large intestine.— At the farther end the small intestine widens out again to form a continuation of the digestive canal, called the *large intestine*, which serves to contain all the waste matters of the food, and absorb any liquid portion of the food that has not already entered the blood vessels and lacteals.

To make such solid bodies as parts of the food are composed of pass through a very fine membrane, it is necessary either to dissolve them in a liquid, or pound them up so fine that the solid particles can pass through or permeate. From the mouth downwards in man we find a very perfect pounding, dissolving, and melting machinery. We grind our solid food with the teeth, and unless this is properly done, it cannot be well digested or got full value out of. Food that is not well masticated may cause certain forms of disease of the bowels. We often find old people without teeth, and others with many decayed and useless teeth suffering from diarrhœa and indigestion; such persons should either be supplied with false teeth, or have their food pounded up fine, before eating it; for, if this is not done, the hard lumps of the food cannot be properly acted upon by the digestive juices. A lot of the food is then wasted, because it is not digested. But grinding the food to the smallest visible particles is not sufficient; it must also be dissolved in water. Many things we use as food require only water to dissolve them—salt and sugar, for instance. The solutions so formed can be taken up or absorbed at once by the blood vessels of the stomach and intestines. But many other bodies, such as beef, mutton, vegetables, rice and bread, will not dissolve in water; they require to be changed by more active agents before they are fit for absorption. These active agents are called the *digestive juices*.

Digestive juices.—These are formed by glands—some small, as those of the stomach and intestines, others large—as the liver and sweet-bread, and salivary glands. Most of these glands are situated along the alimentary tract, from the mouth to the lowest part of the small bowel. We will briefly describe how these juices are formed or *secreted*.

From the mouth to the last part of the bowels there is a thin skin-like structure called the *mucous membrane*. This membrane is partly made up of a thin tissue called *epithelium*, which is composed of cells; beneath these cells the part is arranged to contain glands, which are the organs that secrete the juices. These glands are surrounded by a layer of very minute blood vessels. The cells of the different glands abstract what they want from the blood to form their fluids.

Composition of digestive juice.—The fluids secreted by all the glands is largely composed of water, which serves to dissolve the solid parts formed by the gland cells. These solid constituents are the active parts of the juices. Some of the juices are acid, some alkaline; some act on one kind of food, some on another. Besides these glands

in the mucous membrane of the mouth and intestines, there are other important glands, which pour their fluids into the alimentary tract through little tubes called *ducts* during digestion. These latter glands are those that form the *saliva* which is secreted by the glands situated in and about the mouth,—the *pancreas* or sweetbread, which secretes what is called the *pancreatic juice*; the *liver*, which forms the *bile*; and the *glands of the small* intestine itself, which secrete the *intestinal* juice. It is the combined action of the juices of these glands on the food that is called *digestion*.

Salivary glands.—The salivary glands are situated in and about the mouth. The fluid they secrete keeps the mouth moist, and allows the tongue to move freely in speaking. When we eat hard, dry food, the saliva softens and thereby enables us to swallow it. The chief action of saliva, however, is to *convert starch into grape sugar*, and as we have already said, this form of sugar is able to pass into the blood vessels in solution. By cooking arrowroot, sago, or any other starch, it becomes thick, sticky and tasteless. If we place some of this in the mouth and keep it there for a few minutes, we shall find that the starchy part has become watery—the starch has become converted into a kind of sugar by the fluid poured into the mouth by the salivary glands. This action on starch is not altogether completed in the mouth; it is continued on any undigested starch by the action of the juice formed by the pancreas, which is situated just below the stomach. As a large part of the food consists of starch, it is necessary that the salivary glands do their work properly. We see that *starches* are converted into sugar in the mouth by the saliva and in the small intestines by the pancreatic fluid. This sugar rapidly passes through the mucous membrane of the stomach and small intestine, and so into the blood capillaries of the walls of the digestive canal. Thus, all the good parts of starch and all the sugar we eat, pass at once into the blood.

Action of the gastric juice.—The *gastric juice*, secreted by the stomach, dissolves all *proteid* or meaty substances, and some of the nitrogenous part of vegetable food. If we took a piece of meat and placed it in gastric juice, we would find that the meat would disappear, it would all dissolve, except the fat and the shreddy covering of the muscle fibres. In this dissolved state it is ready to enter the blood, and is taken up by the blood vessels. The juice secreted by the pancreas, called the *pancreatic* juice, in addition to acting on starches like saliva, acts on fleshy substances in the same way that the gastric juice does, and it will also help bile to split up fats and prepare them for entering the *lacteal* vessels through the *villi*. These are vessels which take up a milk-like substance from the small intestine. This milk-like material enters the lacteals, and then passes into larger similar vessels which end eventually in a vein at the bottom of the neck, and thus the fats and some other bodies are at length conveyed to the blood.

Proteid, meaty, or fleshy foods are dissolved in both the gastric and pancreatic juices; the dissolved part readily passes into the blood vessels. *The fat* cells are broken up by the stomach, their envelopes dis-

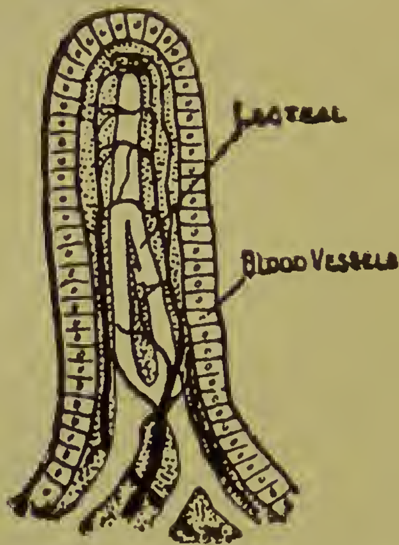

FIG. 34.—Villus, highly magnified (after PROUT).

solved, and the fat globules set free. The bile and pancreatic juice split these into much smaller globules, and these tiny particles of fat pass into the lacteals and then into the blood. The *mineral matters* of the food are dissolved by all the juices and pass at once into the blood. *Water* passes into the blood vessels along the entire digestive tract.

Digestion of bread and chappatties.—Let us follow a piece of bread and meat through the food canal. *Bread* and *chappatties* consist largely of starch. While we are masticating a piece of bread, it is becoming moistened by the saliva and some of the starch is changed into sugar. All of it is softened and partly broken up. In the stomach the vegetable proteid of the bread (gluten) is dissolved, and it, with the newly-formed sugar, enters the blood vessels. The part not acted on is converted into a pulp, called *chyme*, which passes into the small intestine, and is there acted on by the juices of the small intestine and pancreas, where it is dissolved and finds its way into the liver and then into the heart and general circulation. The greater part of the proteid or albuminous matter of bread is not digested, but passes out of the bowel.

Digestion of meat substances.—*A piece of meat* is first broken up into little masses by the teeth, and moistened by the saliva, but undergoes no other change in the mouth. In the stomach the proteids rapidly disappear under the action of the gastric juice; the little masses of meat soften, the fibres of the muscle break short off and come asunder, the fat of the meat is set free from the little cells in which it was stowed, and melts under the heat of the stomach. Most of the dissolved proteid material is absorbed; the remainder passes into the small intestine, and is acted on by the bile and pancreatic juice; these convert the fats into a sort of soapy emulsion, in which form it is absorbed. When all these products are mixed together, we have formed a kind of yellowish cream-like material, which is passed along the bowel by the contractions of the muscular coats; and, little by little, all the good material is taken up by the blood vessels along the entire alimentary tract. At last nothing is left but the indigestible coverings of the starch granules and broken fibres of hard animal and vegetable tissue, which are cast away.

Comparative digestibility of different foods.—The comparative digestibility of different articles of diet is shown in the following list :—

	Hours.	Minutes.
Rice boiled soft	1	0
Apples, sweet and ripe	1	30
Sago, boiled	1	45
Tapioca, barley, stale bread, boiled milk, bread and milk, cold cabbage with raw vinegar.	2	0
Potatoes, roasted	2	30
Baked custard	2	45
Apple-dumpling	3	0
Potatoes and turnips (boiled), butter and cheese	3	30
Tripe and pig's feet	1	0
Venison, broiled	1	35
Cod fish (boiled), eggs (raw)	2	0
Turkey, goose and lamb	2	30
Eggs (soft boiled), beef and mutton (roast or boiled) and oysters (raw).	3	0
Boiled pork, stewed oysters, eggs (hard boiled or fried).	3	30
Domestic fowl and duck (roasted)	4	0
Wild fowls, pork (salted and boiled)... ...	4	40
Veal, roasted; pork and salted beef	5	35

Structure of the teeth.—Each tooth consists of 3 parts—a *root* or *fang* which fits into a socket of the jaw-bone, the *neck* and the *crown*. The incisors and canines have only one fang, the molars in some 2 and in others 3, and the wisdom teeth 4. The nerves and blood vessels enter at the end or apex of the fang. The teeth consist chiefly of a hard tubular substance called *dentine*. This is covered on all exposed parts with a hard, white and brittle material called *enamel*. If this outside

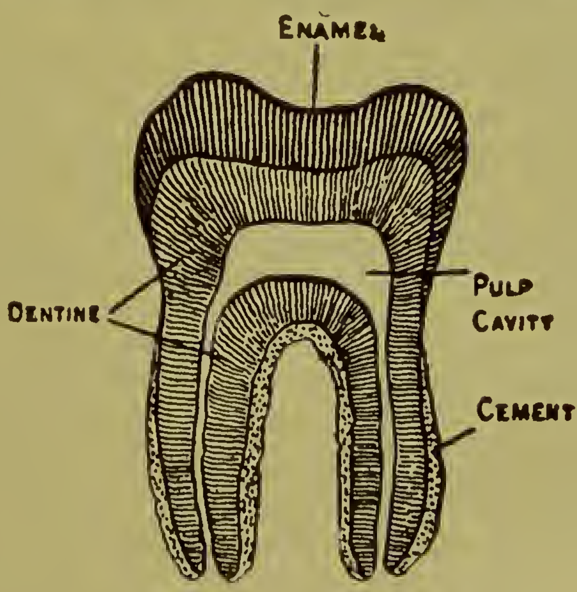

FIG. 35.—Section of tooth (after PROUT).

covering becomes chipped or damaged, it does not grow again. In the centre of each tooth is the *tooth pulp*, which is a soft mass of nerves and blood vessels, the latter serving to nourish the teeth. The fang is united to the jaw-bone by a thin membrane called the *cement substance* or *cementum*, which is like bone in structure.

The enamel of the teeth, although very hard, is also very brittle, and will not stand rough usage. The teeth should not be used for cracking nuts or biting very

Fig. 36.—Scrapings from the teeth containing several different kinds of bacteria. Highly magnified.

hard substances or thread, and gritty tooth powders should not be used. We should not use sharp pointed metallic articles, such as pins or needles to pick the teeth with, they wear away the enamel. Once the enamel is broken off and the dentine exposed, the latter may decay very rapidly creating hollows in the tooth and toothache. We should have the teeth seen to periodically by a dentist; there may be nothing wrong with them, but if there is, he detects it at once and checks the process of decay.

It is impossible to attach too much importance to proper mastication of the food. To the soldier on field service one looks upon it as most essential to keep free from the various intestinal derangements to which life in camp renders a man liable, and the thorough mastication of food helps to do so.

Decay of teeth.—The teeth are provided us for the purposes of cutting and grinding our food. It is necessary that we take every precaution to preserve them in a sound state. Caries of teeth is so universal that it may be useful to briefly allude to it. The process of caries, or decay of teeth, is a chemico-parasitic one, carried out in two stages, the first of which is the removal of the enamel (the hard outer covering of teeth) and dentinal tubules (the less dense substances beneath the enamel) by solution; and the second, the eating away of the soft parts of the tubules and pulp by microbes. In the ordinary process of eating, a certain amount of food remains behind after each meal, remaining in the mouth and becoming entangled between the teeth, which from the heat and moisture of the mouth rapidly decomposes. Further, as the saliva evaporates, it leaves a deposit on the teeth called *tartar*. This tartar collects organic matter and germs. Much of this consists of the particles of food remaining in the mouth, starch which ferments and forms acids—the starch under the action of the saliva is converted into grape-sugar, and this by the action of different kinds of bacteria is converted into lactic acid. Some of the bacteria of the mouth may, however, without the action of saliva, convert starch into lactic acid also. This lactic acid acts on the lime salts (of the enamel and dentine), effecting their solution (decalcification), and then microbes enter and digest the soft parts in the dentinal tubules. Eventually

the pulp is exposed and the process of eating up or digestion by bacteria continues. Many specimens of bacteria inhabiting the mouth may thus eat away the soft part of the teeth. The initial causes leading to caries are chiefly deformity of the teeth, a deficiency of lime salts, existence of pits or fissures in the teeth which lodge starchy food, acid foods and drinks, neglect of cleaning the teeth regularly, etc. Decay is due chiefly to external causes and may occur with perfectly developed teeth in persons in excellent health and physique, and who keep their mouth and teeth thoroughly clean. Dental caries is, of course, inseparably associated with the bacteriology of the mouth. The mouth cavity is usually crowded with microbes, and the more diseased it is, the greater their number; some of these microbes are disease-producing, others innocent.

Preservation of teeth.—The teeth should be brushed with sterilised water and some form of fine tooth powder or antiseptic tooth wash once a day at least; and all particles of food that lodge between the teeth should be removed with a quill or a wooden toothpick. We should not use sharp-pointed metallic instruments for this purpose.

Effects of eating too rapidly.—We ought to take time in eating our food. By "bolting," or imperfectly chewing our food before swallowing it, we do not give time for the saliva to mix with it properly; the coarse pieces of food that are thus swallowed resist the action of the digestive juices. Quick eating leads to over-eating and over-loading of the stomach. We do not, then, really know the quantity we have eaten until we feel an uncomfortable fulness about the stomach. This habit finally leads to dilatation of the stomach connected with which is indigestion and a train of other evils.

Meals—periods of day for taking them.—We cannot lay down any fixed rules as to the hours of the day at which meals should be taken, or the number of meals to be consumed. These points are regulated by convenience, occupation and caste; we shall therefore confine ourselves to a few general remarks. As a rule, we ought not to take more than three meals a day, and most people are better with two. We condemn the custom of eating "little and often." The stomach, like all other organs, requires intervals of rest. There should be an interval of at least four to five hours between meals. This does not, of course, apply to invalids, convalescents, and sick people generally, as they require to be fed oftener and in small quantities. Between the periods of the ordinary meals nothing should be eaten. The time of taking the last meal is regulated by habit and occupation. As a rule, it should not be later than seven o'clock in the evening. On field service we may, however, in this matter have to be guided by circumstances. Certainly no heavy food or large meal should be eaten immediately before going to bed.

Food should be taken with regularity and at proper intervals. The timing of the meals of the European soldier is at present a grave defect. The official meals of the European soldier are—*breakfast* at 8 A.M., dinner at 12-30 to 1 P.M., and an evening meal (*K. R.*, 1908, § 1159).

Under this distribution of meals the European soldier for practically 18 hours depends more or less on personal non-official sources for his food. Unless he provides himself with a supper or evening meal, he starts his day having had no food since the previous mid-day, except some weak tea and what he can have saved from dinner. To make up for this void the temptation is great to fill himself with beer during the evening and under circumstances when alcoholic drink is bound to have its maximum intoxicating effect. The custom of opening the regimental canteen during mid-day before dinner should be stopped. The men who use it drink beer when hungry, lessen their ability to digest food by diluting the gastric juice, and lose appetite. Alcoholic beverages, if used, should be taken *with the dinner*.

The remedy for these two defects is to issue the main meal in the evening, say, at 5 to 6 P.M. The present mid-day meal could be well substituted by some bread, butter and cheese, with some beer if this is considered necessary. This change should anyhow be tried. From a physiological and hygienic standpoint it has all in its favour.

How meals should be taken.—Meal times should not be used for mental work. All serious thinking at this time impairs the appetite and hampers digestion. Cheerfulness is very desirable during these periods. It was intended by Nature that we should enjoy eating since a sense of taste has been provided us.

Exercise before and after meals.—As soon as food is eaten, the digestive tract is at once supplied with an extra quantity of blood, partly at the expense of the other organs of the body. We should not therefore undertake any hard study, labour, or exercise, immediately before or after meals. It is advisable to give the stomach at least a short rest at these periods. Active exercise immediately after a meal disturbs digestion. But persons in health may do anything that does not require severe exertion. When the active part of digestion is over, we feel once more invigorated and fit for work, whatever it be. Never eat a full meal when in a state of bodily fatigue, as in this condition the digestive process is slow. (See p. 71.)

Surfeits of food harmful.—It is almost unnecessary to insist on the avoidance of a surfeit of food at all times. This is particularly necessary when men are exhausted and have to cook and eat hurriedly to ensure getting enough sleep before they will be required for duty again. A really full and hearty meal should never be taken immediately after severe fatigue, or during physical exhaustion. In India the danger is from over-feeding, not deficiency of food. The great defect is the scarcity of fresh vegetables in the hot weather.

When excess of food is taken there is non-absorption of the excess with chemical changes in the digestive tract, and putrefactive processes. Dyspepsia, constipation, and irritation causing diarrhœa are produced. If absorption does occur, strain is

thrown on the eliminating organs; albumen occurs in the urine after a surfeit of eggs, sugar in the urine after great excess of sweets or starches. Habitual over-eating leads to fatness, rheumatism, etc.

It is specially important for the European to avoid over-eating on first coming to India. The whole digestive system is undergoing a change, one special effect of which is that the liver is subjected to a strain by the climate in getting rid of the waste products of digestion. The use of excess of animal food is specially to be avoided. The beef and mutton are neither as nutritive nor as digestible as those of temperate climates, and should be taken in moderation. A small reduction in animal food and a larger allowance of vegetables and fruit is all that is usually necessary. Meat meals three times a day are not suitable for the Indian climate, and tend to keep the work of the liver in a state of high pressure to get rid of the excessive amount of effete material created. Should anything happen to interfere with this work, the liver breaks down in the process. It is a sound physiological rule to observe simplicity in diet. Highly seasoned dishes, greasy messes (whether made with butter, ghee, fat or oil), pastry, *rechauffés* and excessive use of condiments, are to be eschewed. The chief defect in the diet of the European is that he takes too much nitrogenous food and fat. The chief defect in the diet of our rice-eating Indian soldier is a deficiency of nitrogen, and too large an amount of carbonaceous material.

The food should be so prepared as to be eaten with enjoyment and relish. Hence the necessity of understanding, anyhow, the first principles of cookery. It is also desirable that officers should be acquainted with the details of the culinary processes carried out in the soldier's kitchen, and interest himself in these by occasional visits to the kitchen while the preparation of the food is in progress. The work carried out in the kitchen has an important bearing in efficiency. Monotony in diet, unsavoury preparation of food, insufficient cooking, and other defects, are often associated with increase of sickness rate, and a general loss of stamina of the men.

The nature of the food materials sold to men by hawkers and others in cantonments and in camps requires constant watchfulness, especially in such things as sausages, meat pies, *kababs*, fish (fried, dried, salted), ice creams, milk, confectionery of all kinds, and fruit. "The greatest danger to the European soldier in India by means of his food is the ubiquitous presence of cook-boys and other low-caste natives in and about the lines."

Variety of food is necessary.—Few things impair appetite so much as sameness of diet. Nature has provided a great variety of foods for us of which we should take advantage. By the processes of *assimilation,** *metabolism* † *and nutrition* ‡ food is changed into flesh and blood. Say, we eat a meal of meat, vegetables, and some liquid; the former two are ground by the teeth, mixed with the saliva, and all are churned, and dissolved by the digestive fluids, absorbed by vessels of the stomach, and, finally, swept through the body as blood. As the blood passes it, each organ takes up its special food. Within the cells of the organs it is altered into different forms of protoplasmic matter—hard bone for instance, or soft delicate brain tissue, into tears, perspiration, into bile for digestion, oil for the hair, or nails for the fingers.

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* *Assimilation* is the process of transforming food into such a nutrient condition that it is taken up by the circulating fluids of the body and converted into an integral part of the economy.

† The term *metabolism* is applied physiologically to different phenomena which result from the chemical changes in animal cells, or in the substance surrounding cells.

‡ *Nutrition* is the assimilation of nutritive material by the organs and tissues of the body.

Abrupt changes in diet injurious.—It may be remarked that the human economy dislikes abrupt changes in its habits, in its diet especially; therefore the food of the soldier in the field should not be a sudden departure from that to which he is accustomed. A sudden change of staple articles is particularly resented by the alimentary tract and our organism generally, and should be avoided.

J.—Quantity of Food required.

Quantity required varies with circumstances.—The quantity of food required to keep the vital processes in action in health varies with the occupation, habits of the individual, and with the climate. A sedentary calling needs less food than an out-door life. A laborious occupation calls for a supply of force-producing food, such as fatty material and starches, with a sufficiency of animal food. An increase of work requires a corresponding increase in the total amount of food taken, and this increase should be in all the classes of food materials in due proportions and not in any one class. Youths relatively to weight require more food than older men. The *season* should also cause us to modify our diet. In winter we require carbonaceous food and more meat than in summer. In the hot weather we should take less meat, fatty and starchy food, but more fruit and green vegetables. *Climate* also has its necessities. The people living near the North Pole have a great liking for fat and oils. In India the diet should consist of more vegetable than animal matter, *i.e.*, it should be less stimulating.

It is doubtful, however, whether climate has any great influence on the question of food materials required, except in extreme cold. "Man is capable of adjusting his temperature to that of the surrounding medium, not by increasing or diminishing the amount of heat he produces from his food, but by the regulation of heat loss by clothing In very cold climates the demand for heat is so great that it cannot be met by diminishing loss; the deficit is made up by an increase of heat production by a greater consumption of food, particularly fatty food. Similarly in hot climates the demand for heat is so small that it can no longer be adjusted by an increased loss; in this case man instinctively avoids the nitrogen containing foods and the fats, or those nutritive constituents from which a large amount of heat can be produced in a short time, but the proportion of vegetable food-stuffs is relatively increased.

General principles of diet.—The general principles of diet are:—That (1) no single nutritive principle, whether nitrogenous or non-nitrogenous can support life except for a short time; (2) life may be supported upon one nitrogenous and one non-nitrogenous principle for a long time, but for a permanency salts would have to be added—thus proteids and fats, or proteids and starches, would support life; (3) for the best forms of diet both fats and carbohydrates are needed in addition to nitrogenous matter, and in all probability both starch and sugar among them. It would also appear that a due admixture of more than one form of nitrogenous principle is advisable.

To maintain a man in perfect health it is necessary that his food should contain examples of the five different sorts of food-stuffs enumerated on p. 168 proteids, carbo-hydrates or sugars, hydro-carbons or fats, salts, and water. The first three classes serve as sources of energy to the body.

The nutritive value depends on the carbon and nitrogen contained.—The nutritive value of a diet depends chiefly on the amount of carbon and nitrogen it contains. A man doing a moderate amount of work will eliminate, chiefly from the lungs in the form of carbonic acid, from 250 to 280 grammes (about 3,750 to 4,200 grains) of carbon daily. During the same time he will eliminate, chiefly in the form of urea in the urine, about 15 to 18 grammes (roughly 225 to 270 grains) of nitrogen. These are derived from the metabolism of the tissues, and various forms of energy (mechanical motion and heat being the chief) are simultaneously liberated. During muscular exercise the output of carbon greatly increases, the increased excretion of nitrogen is not so marked. Taking then the state of moderate exercise it is necessary that the waste of the tissues should be replaced by fresh material in the form of food, and the proportion of carbon to nitrogen should be the same as in the excretions—250 to 15, or 15·6 to 1. The proportion of carbon to nitrogen in proteid material is, however, 53 to 15, or 3·5 to 1. The extra supply of carbon must be derived from non-nitrogenous foods—fats and carbo-hydrates.

Carbon and nitrogen required in diets.—A healthy man doing ordinary work requires roughly in his diet about 300 grains of nitrogen and 4,500 grains of carbon. The dietary of the British soldier approximately contains these quantities.

The energies of the body can only arise from the food consumed. Hence the nutritive value of the various food-stuffs is the same as their value as force producers. The simplest measure of the amount of power or energy which can be obtained from a given weight of matter is the heat provided during its combustion. As a standard or measure of heat yielded by the combustion of food we have the *calorie*, which represents the heat required to raise 1 kilogramme or litre (35 ounces) of water 1° C., or, in other words, 1 lb of water 4° F. The mechanical equivalent of this amount of heat is 3,058 lbs, raised 1 foot or 1·3 foot tons. In the case of the majority of food-stuffs their actual value in respect of capacity for heat production has been determined experimentally and expressed in relation to the performance of work; thus it has been calculated that an ounce of the following substances, on complete combustion, yields the amount of energy expressed in *calories* stated:—Arrowroot, 96 calories; bacon fat, 252; lean beef, 29; bread, 85; butter, 249; cheese, 116; macaroni, 95; milk, 20; oatmeal, 124; potatoes, 27; rice, 98; sugar, 115; tapioca, 98; and veal, 25. These figures show the amount of energy obtainable from the food, but not the real amount it actually furnishes in the body. To be used as actual energy in the body, the food must first be digested and assimilated, and then its energy must be generated at the place and in the way that is suitable for nutrition. The actual potential energy of food-stuffs as tested outside the body cannot be used as the only basis upon which to fix dietetic standards.

In the body one-sixth of the total available energy of food is transferred into work, the rest being lost in the form of heat. In a steam engine only one-eighth of the potential energy in fuel is consumed.

The different classes of food-stuffs must be in certain proportions to carry out the work of nutrition properly. All classes of food-stuffs are to be represented in a proper dietary. No single class can carry on the functions of the body except for a short period. A diet of the nitrogenous and one of the non-nitrogenous foods may carry on life for a long time, such as *dal* and rice, but on such a diet the stamina would run down.

Bases for estimating the quantity of food required.—There are four different methods of ascertaining the value of a dietary:—The

chemical, depending on the nutritive value of the different classes of food-stuffs in the diet; the *physical*, which estimates the value of the food by the actual amount of heat produced when it is completely burnt up—this calculation being carried out in the chemical laboratory; the *physiolcaical*, which is based on the degree to which the food is assimilated or used in the body; and the *economic*, that is, the nutritive value of the food as compared with the cost (R HUTCHINSON).

Nutritive and chemical value of a diet.—As previously stated the nutritive value of a diet depends chiefly on the amount of carbon and nitrogen it contains.

Chemical Compositions (approximate) of certain Food Substances.

	PER CENT. OF					GRAINS PER POUND.	
	Water.	Nitrogenous.	Fatty.	Carbohydrates.	Salts.	Nitrogen.	Carbon.
Good meat,* beef or mutton, a little fat, uncooked.	75	20	3·5	...	1·5	190	1,900
Average meat,* uncooked.	75	15	15	...	3	...	...
Very fat meat ...	63	14	19	...	4	...	...
Veal	71	17	11	..	1	...	...
Fat pork ...	40	10	50	...	2	100	4,000
Dried bacon ..	22	8	65	...	44	...	...
Salt pork† ...	45	25	7	...	25	290	1,360
Pork (medium fat) ...	61	12	26	...	0·6	...	...
Salt beef ...	50	20	0·2	...	20	325	1,115
Lamb (medium fat)...	64	18·5	15·5	...	1·1	...	...
White fish ...	78	18	3	...	1	200	875
Eggs	74	14	11·5	...	1	...	...
New milk ...	87	4	3·5	5	0·5	45	600
Skim milk ...	90	4	2	5	0·8	45	450
Cheese	37	33	24	...	5·5	..	3,300
Butter	6	0·3	91	...	2·5	...	6,500
Bread ...	40	8	1·5	50	1·5	90	2,000
Flour	15	11	2	70	1·7	120	2,700
Oatmeal	15	13	6	65	3	140	2,800
Bajri	11·8	10·13	4·86	71·75	1·7	...	...
Indian meal ...	14	10	7	65	1·5	120	3,000
Dal	11·84	25·15	1·26	59·85	1·92	...	...
Peas (dry) ...	15	32	2	55	2·5	250	2 700
Gram	11·39	20·70	3·86	62·18	2·0	...	...
Green vegetables ...	90	0·2	0·5	6	0·7	14	4,200
Carrots	85	0·6	0·2	8·5	0·7	14	5,000
Potatoes ...	75	1·5	0·1	23	1	22	770
Rice	10	5	0·8	83	0·5	70	2,700
Sugar	3	...	...	96·5	0·5	...	3,100‡

* Twenty per cent. should be allowed for bone, and 20 to 30 per cent. more is lost in cooking.

† Brine dissolves out myosin and other important constituents. The nutritive value of salt meat is not more than ⅔ that of fresh meat.

‡ Milk-sugar yields only 800 grains of carbon per pound.

This table gives us a means of ascertaining to what extent a given scale of food answers to the requirements of a suitable dietary in any particular case From it also we can construct a dietary that will meet the conditions required under different forms of work. For example, were we to enquire how far a diet or, say, 2 pounds of bread and 8 ounces of cheese fulfils the requirements of a diet for moderate work, the chemical basis would be as follows :—

	Proteid.	Fat.	Carbo-hydrate.
	oz.	oz.	oz.
100 oz. bread contains ...	8	1½	50
Therefore 32 oz. contain ...	2·5	0·5	16
100 oz. cheese contains ...	33	24	0
Therefore 8 oz contain ...	2·6	1·9	0
Whereas the theoretical amounts required for moderate work are	4·5	3	15
32 ozs. of bread and 8 ozs. of cheese contain.	5	2·4	16

Hence such a diet is sufficient as regards proteid matter and carbo-hydrates, but wanting in fat.

We may make the same kind of calculation from the actual amount of carbon and nitrogen in the different articles of diet, for example :—

	Nitrogen. Grains.	Carbon. Grains.
1 pound bread contains ...	90	2,000
Therefore 2 pounds contain ...	180	4,000
1 pound cheese contains ...	300	3,300
Therefore 8 ounces contain ...	150	1,650
32 ozs. of bread and 8 ozs. of cheese contain.	330	5,600
The theoretical amounts of carbon required for moderate work are	300	5,000

Hence, if we leave out of consideration the differences between fats and carbo-hydrates, the diet more than satisfies requirement as regards nitrogen and carbon.

In the same way given a full table of the percentage composition in proximate principles of the indigenous food products of India, we can readily calculate an approximate diet for any class of persons (Native soldiers, prisoners, etc.), if we are acquainted with the amount of work the men are required to carry out.

Regarding the chemical investigation of diets the best authorities consider the following quantities of the different classes of food-stuffs necessary for the adult man of ordinary size during rest, moderate work and hard work.—

Nature of work.	Nitrogenous food.	Carbo-hydrates.	Salts.	Fat.	Such a diet would contain. Nitrogen.	Carbon.
	oz.	oz.	oz.	oz.	Grains.	Grains.
Rest	3	12	1	1½	200	4,000
Moderate work ...	4½	15	1¼	3	300	5,000
Hard work ...	6	18	1½	4½	400	6,000

The amounts represent ounces of *dry* (water-free) food-stuffs. The nitrogen for hard work is probably in excess, whilst the carbon for hard work is probably less than is required.

From this table we notice that a healthy adult man during moderate work requires 4·5 ounces of nitrogenous or proteid material (in the form of meat, eggs, fish, *dal*, etc.), 3 ounces of fat (butter, ghee vegetable oils etc.), and 15 ounces of starch (bread, rice, etc.), and about an ounce of salt; this is equal to from 23 to 24 ounces of dry food, and equivalent to about 300 grains of nitrogen and 5,000 grains of carbon. To this in an ordinary diet we may add 3 to 4 pints of water.

A perfect food is one that contains the right proportion of the substances needed by the body for the production of energy and heat, and for the repair of waste and building up of new tissue. Hence it is that with a proper mixture of the different kinds of food stuffs, or a mixed diet, the human system can best carry on its nutritive processes in the most economical way.

The physiological requirements of the body demands a ratio of 1 part of nitrogen to 15 or 16 parts of carbon. Hence as the food-stuffs are blended in proportions different to these, a mixture of them is required to get these proportions. This mixture may be of animal and vegetable food-stuffs, or of food-stuffs derived entirely from the vegetable kingdom.

Estimation of mechanical work done by the body.—In estimating the work done by the body we take into account the work done by the muscles of respiration and circulation, as well as the more visible work of locomotion, etc. The force exerted in breathing, and in the action of the heart per day in an adult is equal to about 260 foot tons; this is the *internal work* of the body.

Suppose we were estimating the amount of work done in locomotion. Here we have likewise to include the actual weight carried. Walking along a level road at the rate of 3 miles an hour is considered to be equal to climbing vertically $\frac{1}{20}$th of the distance travelled; if at the rate of 4 miles an hour, it is equal to $\frac{1}{16}$th, 5 miles an hour, $\frac{1}{14}$th, and so on.

From this it is possible to calculate the amount of physical work done. Suppose a man weighing W pounds carries a load of W pounds on a level road for D feet at the rate of 3 miles an hour, the energy exerted is equal to

$$\frac{(W+W)D.}{20 \times 2240 \text{ (lbs. in a ton)}} = \text{foot tons.}$$

If, for instance, a man weighing 150 pounds carries a load of 60 pounds on a level road for 20 miles at the rate of 3 miles an hour, the work done is equal to

$$\frac{(150+60) \times (5280 \times 20)}{20 \times 2240} = 500 \text{ foot tons.}$$

In ascending a perpendicular height a man, of course, carries his whole weight, in which case the 20 of the denominator would not be used. The energy expended in a fair day's work is about one-sixth mechanical labour to five-sixths heat produced in the body. The value of the food may also be ascertained by estimating its physical equivalent as heat on being burnt up. The diet of an adult man doing moderate work should yield sufficient energy to maintain the nutrition of the body, the integrity of the tissues, and the repair and wear and tear. The average required of the different classes of food-stuffs for these purposes is 125 grammes * of proteid, 500 grammes of carbo-hydrate, and 50 of fat.

The potential energy of the food is calculated in what are called *calories* (p. 217); the potential energy of the food should contain 3,500 calories for moderate work. The energies generated by the food are, of course, used in other ways, besides the production of heat, as in mechanical energy, etc.

1 gramme or $15\frac{1}{2}$ grains of	Proteid ...	...	= 4·1 calories.
Do.	Carbo-hydrate	...	= 4·1 ,,
Do.	Fat ...	...	= 9·3 ,,

* One gramme=$15\frac{1}{2}$ grains.

Multiplying the percentage of proteid and carbo-hydrate which a food contains by 4·1 and the fat by 9·3 gives the total calories per 100 parts of the food in question. Thus, 100 grammes of milk contain 2 of proteids, 4 of fat, and 6 of carbo-hydrate, the calories of the proteids would be 8·2, of the fat 37·2, and of the carbo-hydrate 24·6, or a total of 70·0 per 100.*

The standard diet scale mentioned yields carbon, nitrogen and calories as shown in the following table:—

	Carbon grammes.	Nitrogen grammes.	Calories grammes.
Proteïd, 125 grammes ...	62	20	512 5
Carbo-hydrates, 500 grammes...	200	...	2050
Fat, 50 grammes ...	38	...	465
Total ...	300	20	3027·5

These in ounces are 4·4 of proteid, 2·5 of fat, and 18 of carbo-hydrate=24·9 ounces of dry food.

For a person doing no physical work (diet of rest) a diet equivalent to 2,500 calories is required; for moderate work 3,120 calories and for hard labour 5,200 calories.

In all these calculations the food-stuffs are assumed to be dry or completely free from water. The daily food-stuffs used, however, contain at least their own weight of water, so that the solid food would have a weight of 40 to 50 ounces. In addition to this, the adult man drinks from 50 to 80 ounces of liquid daily. A man consumes about $\frac{1}{100}$ of his weight as dry solid food and $\frac{3}{100}$ of water daily.

The figures showing the quantities of proximate principles in standard diets such as these are to a large extent arrived at empirically, or by experience and observation as to what amount of food large bodies of persons have been in the habit of taking. It is accepted that the use of these standards is sufficiently extended to warrant the opinion that the quantities stated of the different food principles are actually taken, and are those demanded in the economy for physiological purposes, and not merely because they are more agreeable to the mass of the people.

Typical diet standards to be treated as rough averages only.—Typical diet standards must not be considered as more than a rough average of what is necessary for a man in the course of the day. In the diets of different nations we know there is great variation from the above standards without producing ill-effects.

* Whitlegge, *Hygiene and Public Health*, p. 93.

Knowing the actual composition of food-stuffs as regards their percentages of proximate principles, it is comparatively easy to work out a diet table for the different conditions of light, moderate, and heavy work.

Scale of rations of soldiers.—All officers of European and Native regiments are familiar with their men's dietaries in peace times, and have a general idea of diets on field service. The scale of the latter varies in different campaigns.

Peace time ration for European troops.—The usual daily allowance for European troops in peace times in India is:—

Meat with bone	16 ounces daily.
Bread	16 ,,
Potatoes	16 ,,
Rice	4 ,,
Sugar	2·5 ,,
Tea	0·71 ,,
Salt	0·66 ,,
Total	55·87

In this diet there are:—

Nitrogen	256·5 grains.
Carbon	4,503 ,,

These articles are provided by the Supply and Transport Department. There are, of course, purchases made by the men in the form of extra bread, fish, eggs, cheese, butter, etc., which brings this ration up to the standard necessary for health. The chief deficiency is in vegetables, which are specially difficult to get in the hot weather.

The weights of the different articles of rations are for the uncooked material except bread Bread is weighed cold when it is lighter than when first taken out of the oven. Meat is issued in joints in bulk for companies or sections. The available meat from an animal in good condition is more than half its live weight, that from one in poor condition is less than half. Losses arise from bone and from shrinkage in cooking.

The nutritive value of the Indian scale of Government ration is 2 636 calories. The nutritive value of the supplemented food in messes varies, as does also that procured by individual men on their own account.

The following is a detail of what was actually consumed by a soldier in India:—

Breakfast—Bacon, 3 ounces, 2 eggs; bread, 4 ounces; tea and sugar.
Dinner—Beef, 5½ ounces; Yorkshire pudding, 4 ounces; potatoes, 8 ounces; bread, 4 ounces.
Tea—Currant cake, 5 ounces; tea and sugar.
Supper—Curried fish, 4 ounces; bread, 3 ounces.

The weights given are those of the cooked food. This man's diet was calculated to be equivalent to 3,090 calories. If we accept the above as being anything like an average day's food for the European soldier in India, we may state definitely

that he is well fed.* There are of course great differences in different regiments and in different individuals. In some regiments the feeding is more elaborate, in others less so. Some men are naturally large eaters, others small. The quality of the food issued to the men in India is on the whole good. Tinned food is not issued in peace times.

Rations of European troops on field service.—For all troops on active service the scale of diet is fixed according to the climate and circumstances of the expedition. The following scale *per diem* is adopted as far as possible:—

Meat, fresh, salt or preserved, 16 ounces; bread, 20 ounces, or biscuit 16 ounces, or flour 16 ounces; tea ½ ounce; coffee ⅓ ounce; sugar 2 ounces; salt ½ ounce; pepper $\frac{1}{36}$ ounce; fresh vegetables (when procurable) 8 ounces, or compressed vegetables 1 ounce.

Half an ounce of lime-juice with ¼ ounce sugar, and 2½ ounces rum is issued when ordered by the G. O. C. on the recommendation of the P. M. O. of the force. Under all circumstances the food-supply in the field should be liberal and all articles should be provided by the Supply and Transport Department. It would probably be a good plan to have the supply under two headings, the "usual" and the "extra" articles, the latter being intended for special occasions, such as forced marches, rapid movements far from the base of supplies, etc. The usual ration ought not to contain less than 375 to 400 grains of nitrogen. The following is suggested as a liberal and varied war ration which could be easily supplied under ordinary circumstances:—

Bread	1¼ lb.
Fresh meat (without bone)	1 lb.
Peas or beans	3 ounces.
Potatoes and green vegetables	1 lb.
Cheese	2 ounces.
Bacon	2 ,,
Sugar	2 ,,
Salt	½ ounce.
Pepper	$\frac{1}{36}$,,
Ground coffee	1 ,,
Tea	½ ,,
Beer	1 pint.

The nutritive value of this diet is:—

Proteids	5·6 ounces.
Fats	3·43 ,,
Carbo-hydrates	16·6 ,,
Salts	1·37 ,,

and it is equal to 410 grains of nitrogen and 5,000 grains of carbon.

The extra articles would be kept in readiness for occasional issue—these would consist of Australian, New Zealand, or other tinned meat, the best procurable in the market; extract of meat, pea and beef

* NOTTER and FIRTH, *Theory and Practice of Hygiene*, 3rd Ed., p. 901.

sausages, biscuits, flour, meat, rice, lime-juice, preserved vegetables, rum and vinegar. "This plan supposes that the usual scale of diet would be issued to the troops, and the 'extra' articles under certain conditions and order of the General of the Division" No spirit ration should be given except under the special order of the G. O. C's of Divisions.

The scale of ration fixed for a campaign is in reality not always what the men receive, as there are many accidents in fighting which interfere with adherence to it. The standard given, however, is what should be aimed at.

The average amount of *external work* of a soldier at ordinary work (parades and fatigues) is 508 calories, therefore the total heat value of his food should not be lower than six times this, that is, about 3,050 calories. For a man on field service or on manœuvres the energy required from the food is about 3,500 calories.

Scale for European troops during Thibet Mission.—The field service diet is modified to suit the local conditions of the campaign. In Thibet, for instance, the scale for British troops consisted of :—

Bread	... $1\frac{1}{4}$ lb. daily.
Fresh meat (inclusive of bone) ...	... $1\frac{1}{4}$,,
Potatoes 12 oz.	... 1 lb.
Mixed vegetables, 4 oz.	
Rice	... 2 oz. three times a week.
Tea	... 1 oz. daily.
Sugar	... $2\frac{1}{2}$ oz. ,,
Salt	... $\frac{1}{2}$ oz. ,,
Fuel	... 3 lbs. ,,
Pepper	... $\frac{1}{6}$ oz. ,,
Jam	... 1 tin ,,

In lieu of 1 lb. of fresh vegetables the following could be issued :—

Potato chips	... 3 oz. daily.
Pickles	... 1 ,, ,,
Pickle vinegar	... $\frac{1}{2}$,, ,,

The daily ration of each officer and man in the Ashanti Expedition (1895-96) was :-- Bread, $1\frac{1}{2}$ lbs., or biscuit, $1\frac{1}{2}$ lbs. ; fresh meat, $1\frac{1}{2}$ lbs., or preserved meat, 1 lb. ; tea, $\frac{1}{2}$ ounce ; cocoa paste, 1 ounce ; dried onions or compressed vegetables, 1 ounce ; preserved potatoes, 1 ounce ; sugar, 3 ounces ; salt, 3 ounces ; pepper, $\frac{1}{36}$ ounce.

In the 1898 Khartoum Expedition the European soldier's ration was :—Fresh meat, $1\frac{1}{4}$ lbs., or preserved meat, 1 lb ; bread, $1\frac{1}{2}$ lbs., or biscuit, 1 lb , tea, $\frac{1}{2}$ ounce.; coffee, $\frac{1}{2}$ ounce, or cocoa-paste, 1 ounce ; sugar, 3 ounces ; salt, $\frac{1}{2}$ ounce; pepper, $\frac{1}{36}$ ounce ; dried onions, 2 ounces, or compressed vegetables, 1 ounce, or fresh vegetables, 1 ounce, or beans, 3 ounces ; preserved potatoes, 1 ounce ; rice, 2 ounces ; lentils, 1 ounce. The ration for Native troops (Egyptian) was :—Bread, biscuit, or flour, 1 lb. ; meat, fresh or preserved, $\frac{1}{2}$ lb. ; coffee, $\frac{1}{3}$ ounce ; sugar, 2 ounces ; salt, $\frac{1}{2}$ ounce.

Meat, and bread or biscuit form the staple articles of food of all European armies in the field. Little effort has been made to utilise such excellent and nutritious articles as oatmeal and cheese. Eight ounces of uncooked preserved meat are ample. An excess of indigestible meat is answerable for much of the constipation and diarrhœa on field service. The field service food is very concentrated, and without that mass which stimulates the bowels to normal activity. After a few months on field service the men have a craving for sugar, starch, fruit in the form of jam, bread and butter.

Rations of Native troops in peace times.—In the Native Army in peace times each regiment whilst adhering to the Regulations fairly approximately regarding the staple articles, has its own scale of diet, which is as a rule fixed only as to the minimum quantity of the staple articles, beyond which they are permitted to use whatever articles of diet they fancy. One is very much disposed to recommend that certain standard scales should be laid down for men of different castes and provinces, these standards to be carefully worked out on the basis of the proximate principles of food-stuffs, due consideration being given to climate, season, locality, a sufficiency of vegetables, and variety in the food.

The general scale of rations laid down in the Regulations for the Native Army in peace times is:—

Flour or rice	2 lbs.
Dal	4 oz.
Ghee	2 ,,
Salt	$\frac{2}{3}$,,

Provisions purchased for Native troops and followers must invariably be surveyed by committees of Native Officers, and should be of the quality usually consumed by the class of man for whom they are intended.

Scale of rations for Native troops on field service.—For the Native Army and followers the scale of diet on field service is fixed previous to entering upon each campaign.

Thibet—In Thibet the ration for Native troops and followers was identically the same, and consisted of:—

Atta or rice	$1\frac{1}{2}$ lbs.
Dal	4 oz.
Ghee	2 ,,
Gur (jaggery)	1 ,,
Salt	$\frac{1}{2}$,,
Tea	$\frac{1}{3}$,,
Chillies	$\frac{1}{6}$,,
Turmeric	$\frac{1}{6}$,,
Garlic	$\frac{1}{6}$,,
Ginger	$\frac{1}{6}$,,
Fuel	$1\frac{1}{2}$ lbs.
Meat (mutton or goat flesh, inclusive of bone)	28 oz. weekly.

Atta-eating men had the option of drawing half a pound of rice instead of similar quantity of *atta*, or *vice versâ*. An issue of rum 1 oz., or tea $\frac{1}{2}$ oz., and *gur* 1 oz., per man, was occasionally made during specially inclement weather to units employed in road-making or other hard work.

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The absence of a reliable antiscorbutic in the rations of Native troops and followers is still a general defect calling for remedy.

In later campaigns onions and *amchur* (sliced and dried mangoes) and *imli* (dried tamarind pulp) have been valuable additions.

Followers' rations usually deficient.—As a rule the general ration of the follower has been deficient in quantity—it should be the same as that of the Native soldier, considering the amount of work most followers are called upon to perform.

With European troops for rapid movements when concentrated and cooked foods are required, the use of pea and flour sausages, erbswurst, meat, biscuits and other forms of so-called emergency rations are the best to use. Various types of these preparations have been suggested, but in this connection one would urge that a greater consideration might be given to the fact that both cheese and bacon are articles of food of high nutritive value, and they should be supplied by food purveyors in a form convenient for field service.

Rations of the French soldier.—Under the present Regulations, in time of peace Government furnishes the meat for the soldiers' rations at about 35 per cent. under market price. The State also furnishes bread (*pain de munition*) and fuel; the white bread (*pain de soupe*), as well as other articles, are bought from the funds of the *ordinaire*, or common fund of the company, battery, or squadron. If biscuit is issued, 19·4 ounces are given instead of bread. If salt beef is used, 8 ounces are issued, or 7 ounces of salt pork. Haricot beans form the chief part of the dried vegetables.

In Algiers the ration consists of bread 26·5 ounces, and 8·8 ounces for soup, or biscuit 643 grammes. The meat is the same as above; 60 grammes of rice and 15 grammes of salt are issued, and on the march sugar, coffee, and ¼ litre of wine.

In *time of war* the normal ration is as follows:—Bread 26·5 ounces, or biscuit 21 ounces, rice 2 ounces or dried vegetables 2 ounces, salt ⅗ ounce, sugar ⅘ ounce, coffee ½ ounce, fresh meat 14 ounces, fat or lard 2 ounces, condensed soup 2⅗ ounces. When fighting is actually going on and great exertion is demanded from the soldier the ration is increased by the following additions:—Rice 3½ ounces, sugar 1 ounce, coffee ⅗ ounce, fresh meat 17·5 ounces, preserved meat 8·8 ounces.

Rations of the United States soldier.—The daily ration in the United States Army *in peace time* is as follows:—

	Ounces.
Fresh beef, 20 ounces, or salt beef ...	22·00
Or pork or bacon ...	12·00
Bread or flour ...	18·00
Potatoes ...	16·00
Peas or beans ...	2·40
Rice ...	1·60
Sugar ...	2·40
Coffee (raw) ...	1·60
Salt ...	0·25

Rations of the German soldier in peace time:—

	Smaller Ration.	Larger Ration, as supplied for Camps, Marches, etc.
	Ounces.	Ounces.
Bread ...	26·27	35·30
Meat (raw) ...	5·30	17·65
Or bacon ...	4·41	6·00
Or smoked meat (only in war time) ...	...	8·82
Rice ...	3·18	6·00
Or groats ...	4·24	6·00

	Smaller Ration.	Larger Ration, as supplied for Camps, Marches, etc.
	Ounces.	Ounces.
Or peas or beans	8·12	12·00
Or potatoes	53·00	71·00
Salt	...	0·88
Roasted coffee (exceptionally—only in war time).	...	1·41
Brandy	...	3·53
Or Beer	...	53·30
Or Wine	...	17·65
Butter	...	1·76
Tobacco	...	1·41

The daily *war ration* is now as follows :—

Bread	26·50
Fresh or raw salt beef	13 25
Or smoked beef, mutton, ham, bacon, or sausage.	8·82
Rice or ground barley	4·41
Or peas, beans, or flour	8·83
Or potatoes	53·00
Salt	0·90
Coffee roasted	0·90
Or raw coffee	1·00

Dismounted troops and field and horse artillery carry iron rations for three days, cavalry for one day ; the dismounted carrying it on their persons, the cavalry on the saddle, and the artillery on their carriages. An iron ration consists of 9 ounces biscuit, 7 ounces preserved meat (or 6 ounces bacon), 3½ ounces preserved vegetables, ⅞ ounce of coffee, and ⅞ ounce salt ; the total weight with the packing is 1 pound 10 ounces. This is a very meagre diet intended for short periods only, and is probably issued under the conviction that there are few parts of Europe in which it could not be supplemented.

Rations of the Austro-Hungarian soldier :—The *peace ration* consists of :—

	Ounces.
Bread	30·88
Or biscuit	17·65
Meat	6·71
Suet	0·62
Wheat flour	6·57
Or legumes	2·47
Or groats	1·94
Or millet	5·29
Or pearl barley	4·02
Or potatoes	19·77
Or rice	3·71
Sauer-kraut	5·54

The *war ration* consists of : –

Biscuit	3·53
Flour	25·20
Beef	9·88
Or salt meat	6·00
Or bacon	6·00
Peas	5·29
Or groats	4·94
Or potatoes	8·82
Or Sauer-kraut	5·54
Suet	1·06

Rations of the Russian soldier:—The daily scale of ration for a soldier in *time of war* is :—

Biscuit	1 lb. 13 oz. (or flour, or bread as in peace).
Fresh meat	$7\frac{1}{4}$ oz. or $3\frac{5}{8}$ oz. ham.
Groats	$4\frac{4}{5}$ oz.
Salt	$\frac{4}{5}$,,
Tea	$\frac{6}{4}$,,
Sugar	$\frac{5}{9}$,,
Spirits	0·27 pint.

Rations of the Japanese soldier.—The daily *ration in peace* consists of rice 36 ounces in bulk. and 6 sens for the purchase of beef, chicken, pork, or fish and vegetables, tea, pepper, mustard, and *miso* (a kind of bean or peas flour).

The daily *field ration* consists of :—

A.—Daily issue.

Rice (uncooked)	1 quart or about 2 lbs.
Tinned meat or fish	$\frac{1}{3}$ lb.
Dried vegetables	$\frac{1}{4}$ lb
Pickles	2 oz.
Sauce (*soyo*)	1 ,,
Bean-meal (*miso*) sauce	1 ,,
Salt	$\frac{1}{2}$,,
Sugar	$\frac{1}{2}$,,
Tea	$\frac{1}{7}$,,

B.—Periodic issue.

Saké (Japanese spirit)	$\frac{1}{5}$ litre or $\frac{1}{3}$ pint.
Fresh meat	1 lb. with bone.
Cigarettes	20

C.—Irregular issue.

Japanese cake	$\frac{1}{2}$ lb.
Fresh fruit	2 or 3 peaches, apples or oranges.

The rice ration is usually two-thirds rice and one-third barley. The pickles are either pickled plums or mixed vegetables.

The preserved vegetables contain cooked potatoes in slices, carrots, sliced pumpkin, and beans. Tea and salt are issued in tablets and cubes. The biscuit is made of wheat, rice, and a little millet, which is supposed to keep it from getting hard. At the canteen the soldier can procure *saké*, tobacco, and a very favourite sweet biscuit. Each man cooks his own rations; only in the artillery are two large iron cooking-pots per battery in use. When the Japanese captured the excellent mobile field kitchens of the Russians, they used them for the boiling of drinking water; otherwise each man had to boil his own drinking water in his copper kettle. An average of 2 ounces of *saké* was allowed to each man in the Japanese Army in Manchuria as an extra under strict superintendence of the medical officers.

During the early part of the Russo-Japanese war, when the staple article of diet was rice only, the number of cases of beri-beri increased; when rice with barley and an increase in the quantity of meat were issued the disease decreased rapidly. At the seige of Port Arthur none of the Naval Brigade got beri-beri, although there were many cases amongst those besieging it from land; but the sailors got 1 lb. of meat, 10 ounces of barley and 20 ounces of rice daily, which seems to show that one of the factors causing a susceptibility to beri-beri is deficiency of nitrogenous food, with an excess of carbo-hydrates (starchy foods).

A good supply of food was procured in addition to the personal rations. When men worked over 8 hours a day they were given an extra ration of about 12 ounces of rice, and one-third of the biscuit ration. The issue of 24 ounces of rice, and

12 ounces barley was made compulsory to prevent beri-beri. In summer about an ounce of vinegar was mixed with every 75 lbs. of rice to prevent it from decomposing. In winter when the food froze readily, a piece of flannel was issued to soldiers to wrap their mess tins up in. As far as circumstances allowed soldiers were ordered to cook their own rice in their own mess tins—and there were therefore very few complaints regarding food among the soldiers. We have previously remarked that the Japanese used Refreshment Stations almost throughout the campaign, some of which were not remote from the fighting line. They were found most useful.

Coffee shops.—Coffee shops with European troops on field service may be a source of convenience, comfort and much usefulness in many ways, if thoroughly organised and regularly supervised by regimental officers; but in the usual way they are run they may be a serious source of disease, under which circumstance they are to be condemned as field institutions. If thoroughly supervised by competent and responsible officers, they are a great acquisition; otherwise they should not be permitted to exist.

Officers' messes.—To all officers of units one would emphasise the necessity of equipping and stocking their messes as liberally as the conditions of the campaign permit, especially as regards quality, quantity and variety of plain and wholesome food-stuffs. A little extra expense in this matter is an economy—with the advantages of a good larder the officer keeps fitter, is more resistant to disease, is better able to rough it whenever it is necessary to do so, and to cope with all contingencies. The same applies to all staffs in the field.

K.—The Emergency Ration.

Concentrated foods, and "iron" rations.—Celerity of movement in modern warfare is of great importance, and when sufficient and proper transport for supplies is not available, or serves to hamper and delay troops, the problem of concentration of the rations of the soldier sufficiently to enable him to carry enough for a limited period has to be faced. Much thought and some experimentation has been devoted to the solution of this question, particularly since the results attributed to the use of *Erbswurst* in the Franco-Russian War. Yet the problem has not been solved definitely—an emergency ration suitable in every respect is still wanting in our Army. There are a large number of "iron rations" of different armies now on the market, which consists of various meats, vegetables and peas sausages, meat powders, meat biscuits, concentrated soups, meat extracts, and different rations made up of two or more preserved food-stuffs.

Essential qualities of a good emergency ration.—An emergency ration should be as light as possible consistent with serving its purposes—having the largest value as a food with the least possible bulk and weight. It should not be too sudden a change from the food to which the soldier is accustomed, otherwise the digestive system will be disturbed, and this at a time when the physical efficiency of each man is of the greatest significance. It should be able to keep, possess some variety, at least in the ways in which it may be cooked, otherwise it palls on the

digestion and leads to loss of appetite. It should be palatable, for if disliked it will be wasted and its theoretical value largely nullified. Hence the value of the condiments usually added to it. It should also have some stimulating properties—a large part of it should be sufficiently solid to need mastication, and help the bowels to act. It should be a cooked dry ration which can quickly be made into soup or stew, or which in the presence of the enemy or the absence of fire, may be eaten cold, with or without a mixture with water. The addition of water is advisable as it gives increased bulk, thereby more satisfaction, and facilitates its digestion. The emergency ration should as far as possible be eaten hot, since heated foods are comforting, stimulating, and economical.

Regarding the total weight of the food itself it is probable that no great loss in body weight will occur within a week if the ration contains eleven ounces *per diem* of dry food, if the different nutritive or proximate principles of a diet are in due proportion.

Emergency ration for British troops.—The general emergency ration of the British soldier has varied considerably in different expeditions.

The emergency ration at present used in the home service is contained in a small tin cylinder divided into two compartments, and weighing 10 ounces. One compartment contains 4 ounces of Pemmican and the other 4 ounces of chocolate paste.*

"The following would be the weight of food which would last a man a week :—Biscuits, 2 lbs. ; pea or flour meat sausages, 4 lbs. ; dried meat, 2 lbs. ; sugar, $\frac{3}{4}$ lb. ; tea, $\frac{1}{4}$ lb. ; cheese, 1 lb. ; total 10 lbs. This weight of 10 lbs., which would be undergoing reduction every day, if properly used by the men, would carry them through a week's labour, and, although a meagre diet, would enable them to do their work." †

Emergency ration, United States Army.—The following ration was elaborated by a Board of Officers of the United States Army some years ago, and was tested on several occasions and found adequate :—

Hard bread	16 oz.
Bacon	10 ,,
Pea-meal	4 ,,
Coffee, roasted and ground, with four grains of saccharine	2 ,,
or	
Tea, with four grains saccharine	0·5 ,,
Salt	0·64 ,,
Pepper	0·04 ,,
Tobacco	0·5 ,,

The potential energy of this diet is high and the available nitrogen is sufficient for the requirements of hard labour. Divided in half it is equivalent to the subsistence diet of physiologists. The components of the ration are packed in small separate packages. This ration was submitted to a careful trial in a troop of cavalry. Five such rations were issued to each man for a ten days' march of 21

* NOTTER and FIRTH, *Theory and Practice of Hygiene*, 3rd Ed., p. 902.
† MUNSON, *Military Hygiene*, p. 279.

miles each, all men being carefully weighed before the march and after. The journey taken was through an uninhabited country where food could not be obtained. The average loss in weight was nearly 3 pounds, but it was unevenly distributed, some losing heavily, some keeping their weight, and 5 actually gained in weight. The losses were greater among the younger soldiers and those of heavier build. The men kept fit and their muscular strength increased about 5 per cent. A control experiment by a party marching parallel and eating a full regulation ration showed that the men lost on an average 1·35 lbs. per man, and their muscular strength was increased nearly 25 per cent.*

In the British Army, as in all other Western Armies, the question of a suitable emergency ration is still in the experimental stage. In comparatively recent times a compressed vegetable, used with compressed beef, has been tried. Bovril cartridges have also been tested. The "Standard Emergency Ration" from the United States was used in the South African War. *Pemmican* has been used by our troops in Indian Frontier warfare, as well as in Africa. It consists of a preparation of beef with fat and salt put up into flattened tins 4½ inches long, weighing 8 ounces. It can be eaten without any cooking, or made into beef-tea, hash, or soup by boiling with vegetables. Analysis shows that it contains sufficient proteids, fats, and salts, for emergency use. The carbo-hydrates (which are absent in Pemmican) are provided in the cocoa and honey paste contained in another compartment of the Pemmican can. With this 8 ounces of hard bread are usually issued for use in an emergency.

The only Army that issues oatmeal on service is the German. It would be an excellent article of diet for the soldier in the field. It contains a certain amount of fat, nitrogenous material and starch.

It has lately been thought that the addition of an extra amount of sugar to the field rations would be a very good change, the sugar taking the place of part of the meat ration. The use of sugar on manœuvres was experimented with by a committee of French Military Medical Officers and well reported on. The soldiers of the Japanese Army in the Chinese War of 1894 carried an emergency ration of rice in a cylindrical case strapped to the knapsack.

Emergency ration for Native troops.—A suitable general emergency ration for the different classes of Native troops is still a want and deserving of serious attention. The Committee appointed to consider the question recommended that every regiment be allowed to select the ration they prefer, these rations to be prepared by the men themselves immediately the regiment receives orders to mobilise, and thereafter every man to always have an emergency ration in his possession, which should be consumed only under the orders of an officer; the ration to be replaced on the first available opportunity after consumption. It was also recommended that the ration should be carried in tins. As the shape of the tins would vary according to the ration selected, it was left to regiments to design their own, and also to settle the manner in which it should be carried.

* MONSON, *Military Hygiene*, p. 279.

The following are the formulæ of different rations for Native troops approved by the Committee :—

(*a*) The *chana ration*.—This consists of 12 oz. of parched husked gram (*dal chabena*) with 4 oz. of *gur*. The *chana* and *gur* should be carried in separate compartments of the tin.

(*b*) The *gur mathi*, or *gur* biscuit ration.—This consists of 1 lb. of biscuits made in the proportion of—*atta* 10 parts, *ghee* 5 to 7 parts, *gur* $3\frac{1}{2}$ parts, and milk 3 parts by weight. Where fresh milk is not obtainable, condensed milk might be utilised.

(*c*) The *chini mathi*, or sugar biscuit ration.—This has the same composition as (*b*) except that *maida* (fine flour) is substituted for *atta*, and sugar for *gur*.

(*d*) The *sattu ration*.—This consists of 1 lb. of a mixture of three parts of fine ground parched barley, and one part of fine ground parched gram, sweetened to taste with sugar.

As sudden changes of diet are liable to disagree in one of various ways, it is desirable that all Native troops and followers should be accustomed in peace times to the description of emergency ration they will have to use on field service. Hence these rations should be used whenever opportunity offers during route marches, manœuvres, field training, and district concentrations.

Existing orders prescribe that every Native soldier and follower should carry on his person on service an emergency ration sufficient for one day's requirements; and as the nature of the ration and the manner in which it is carried (whether in a metal receptacle, a bag or otherwise) must necessarily vary with different classes of Native troops, the choice of both rests with the discretion of commanding officers. The ration has to be one which can be quickly prepared from the articles carried for the purpose by the Supply and Transport Corps, and is to be carried on the person in a suitable receptacle. Some regiments carry this ration in tins, others in flat circular aluminium boxes, others in bags; others again prefer some articles carried separately, *e.g.*, the *gur* in small tins and the *chana chabena* in waterproof bags.

L.—Alcohol.

General opinion of military medical officers.—The question of the use of alcohol on service is much discussed with divergent views. The general opinion of the military medical officers at the present time is that all ranks are on the whole better without it. We have several instances of severe campaigns conducted without it. If there is any use for alcohol it is very limited. It should certainly never be used as

a stimulant to fight on. There are rare occasions when it may be of use. After a very severe day in the field and when no further fighting is expected ; after a forced march, when the physical capacity of the men has been greatly strained ; after exposure all day in rain and the men's clothes have been saturated, when they get into camp and have got on dry clothes it may be given ; or on occasions when the men have worked hard under great strain and have used up their spare physical energy, here it may be given when the work has been finished and the men can rest. Under no circumstance should it exceed a ration equivalent of $1\frac{1}{4}$ oz. of alcohol, which is equal to about $2\frac{1}{2}$ oz. of rum, brandy or whisky.

The problem as to the use of alcohol in the Army in peace and war is such an important one that it may be interesting here to consider some of the salient points which will enable us to form some definite opinion as to the limits of its usefulness.

The active agent in all intoxicating beverages is *ethylic alcohol*. *Chemically*, ethylic alcohol is composed of three elements—carbon, hydrogen, and oxygen, and it is represented by the chemical formula $C_2 H_6 O$. Sugar also consists of carbon, hydrogen, and oxygen. Any substance containing sugar, such as the juices of fruit and certain vegetables, may be caused to ferment; and in the process of fermentation, these elements (carbon, hydrogen, and oxygen) re-arrange themselves in such a way that alcohol and certain other bodies—volatile oils and ethers—are produced : a wine or spirit is the result. In this, the alcohol is the intoxicating body ; the other agents contained in the liquor give it its peculiar flavour or aroma. *Wine* is the fermented juice of the grape ; *toddy* is the fermented juice or sap of various species of palm tree, and so on.

Alcoholic beverages and the production of alcohol.—Other alcohols exist differing in composition, but analogous in nature to ethylic alcohol. One example of these is *methylic* alcohol, which constitute the greater part of methylated spirit, another is *amylic* alcohol or fusel oil, which constitutes an impurity in whisky. They are all more deleterious than ethylic alcohol, and have special poisonous properties. Beside ethylic alcohol, intoxicating liquors usually contain some colouring matter and saline bodies. In a general way, we may say that *spirit* such as *brandy*, *whisky* and *gin*, if pure, contain no starch and very little sugar ; *rum* contains an excess of sugar ; *wines*, chiefly saccharine matter, saline bodies with ethers, and essential oils. Ale, stout, and porter contain much starchy and extractive matter.

General effects of alcohol.—The effects of alcohol vary chiefly with the quantity and the form taken. The *first effect* of any alcoholic beverage is that of a stimulant. If taken in small quantities, some of it is at once absorbed by the blood vessels of the stomach, and soon conveyed all over the body. It excites the action of the heart, which pours larger quantities of blood into the brain and other organs. Further, by dilating the smaller vessels of the skin, and allowing a larger amount of blood to flow near the surface of the body, a feeling of general warmth is produced. The red face of those who are constantly taking alcohol is due to the dilated condition of the vessels of the skin. But no fresh heat is developed ; the contrary is the case, for more blood being in the surface, more heat is lost by evaporation and radiation ; the blood, therefore, cools faster than usual. Reaction sets in by which a chilliness is felt, and at this stage, instead of the temperature of the body being normal (98·4 Fahr.), we may find it at 97° or even lower, and it will be several hours before the natural temperature is reached again.

Effects of alcohol on digestion.—When a small amount of any very diluted alcoholic beverage is drunk, it causes an increased flow of gastric juice. The effect of this is to cause the food to be more rapidly and thoroughly digested. On the other hand, if any strong alcoholic beverage is taken with the food, it tends to destroy the activity of the gastric juice, for by it the *pepsin* is thrown down and rendered useless. Pepsin is the ferment substance and active principle of the gastric juice which digests the proteid substances ingested, forming what are called *peptones*. A peptone is a proteid solution obtained by digestion, natural or artificial Without pepsin we know that gastric digestion cannot go on. Further, alcohol unites with water very greedily, and when taken on an empty stomach, absorbs the moisture from the tissues, irritates them, and eventually produces inflammation of the mucous membrane of the upper digestive tract. If such inflammation goes on for any length of time, the glands of the stomach cease to secrete gastric juice and the food then is not digested. Many of the diseases of the stomach from which some adults suffer are due to the excessive use of alcohol.

Effects on the circulation.—If a sufficient quantity of alcohol is taken, we see a more marked effect than we have related in connection with the stomach. The face flushes, there is a sense of being warmer. We know that all parts of the body are abundantly supplied with blood vessels, the smallest of which, the capillaries, pervade the skin, and form a luxurious network in almost all textures. Every beat of the heart drives blood through this network of minute vessels. The quantity of blood thus supplied depends partly upon the frequency of the pulse. But the arteries, which carry the blood from the heart to the capillaries, are not rigid tubes; they are elastic and muscular, and can alter their size in accordance with the needs of the part they supply. Alcohol has a very marked power of causing the vessels to dilate whenever it is contained in the blood, so that under this circumstance, the minute vessels become turgid and the tissue redder. At the same time, it also acts upon the heart. The contraction of the heart has naturally to overcome the resistance of the vessels, so as to keep up, in them, a certain degree of fulness. When the vessels dilate, they offer less resistance to the heart, and, moreover, the whole mass of blood in them is of necessity greater. Now, to keep the arteries full, the heart must send more blood at each beat, or the pulse-beats must follow one another more quickly. But alcohol acts also on the heart itself and makes it beat faster. The result is that it propels more blood in a given time. Thus we see that one early result of alcohol is to produce dilatation of the blood vessels, both local and general, and to quicken the action of the heart and make it do more work in a given time.

Effects on the action of muscles.—The late Professor PARKES has shown the destructive influence of alcohol upon the power of muscular exertion. He induced three soldiers to take a march of 20½ miles, each carrying his full kit, weighing 51 lbs. They received either coffee, rum, or extract of meat with a little water. The experiment lasted six days, each man receiving one of the three fluids during two of the six days. All three men declared the alcohol to be the cause of early exhaustion, the meat extract being regarded the most valuable and sustaining for muscular work. For persons engaged in laborious work, a moderate quantity—that is, less than an ounce and a half of alcohol—does not appear to have much effect, but where the quantity per diem exceeds two fluid ounces, the capacity for strong and sustained muscular work is manifestly lessened. This effect is probably due to the dulling of the nervous system, which renders the muscles less amenable to the will, and partly to the over-excitation of the heart causing palpitation and breathlessness. Alcohol enables us to draw upon reserve energy, and may thus assist in a single effort of short duration, but it is absolutely harmful to any prolonged exertion. The trapper of North America abstains from alcohol during his day's tramp, although he frequently gets drunk in his hut at night. Exercise has an important influence in modifying the effects of alcohol. Those following sedentary occupations and dwelling in crowded towns cannot oxidise as much alcohol as those doing out-door work, and are therefore much more susceptible to the evil effects of alcohol on the body. The Scotch game-keeper, living and working on the Highland heath, may consume comparatively large quantities of his native whisky and still live to a ripe age—a quantity that would kill the city merchant within a few years. The Russian peasant, whilst leading his simple home life in his village is addicted to taking "nips" of vodki or crude brandy, yet, as a soldier in the Russian Army, when on the march, he is not provided with alcohol.

Effects on the temperature of body.—In moderate quantities it seems scarcely to affect the temperature of the body; in larger doses it lowers it slightly in some cases; in poisonous doses the body is greatly cooled. During the glow that follows tho imbibition of small quantities of alcohol, there is a feeling of increased warmth, but even this is delusive and due merely to the dilatation of the surface vessels. A delicate thermometer placed under the tongue of an inebriate tells us that the temperature is below the normal. It has been shown that during digestion of all kinds of food, the bodily warmth is slightly raised; the reverse is the case with alcohol. From half an hour to three hours after it is absorbed the temperature is lowered, and this lowering is in exact proportion to the amount of alcohol taken. It naturally follows that, contrary to popular opinion, alcoholic liquors do not fortify against cold. The habit of taking a "peg" before going out at night is the best possible way to promote chilliness of the body. It is a harmful practice, as the suddenly dilated vessels, in contact with cold air, are made to contract, and the regurgitating cold blood is liable to set up internal inflammations. Dr. HAYES, the Arctic Explorer, holds the opinion that alcohol is not only completely useless, but positively injurious to travellers in Arctic countries. He says that "strong able-bodied men become utterly incapable of resisting cold in consequence of the long continued use of alcohol." Dr. McKAE said that the moment one of the men in the Arctic exploration had swallowed a drink of spirituous liquor, it was certain that his day's work was nearly at an end, and that "it was absolutely necessary to enforce total abstinence to finish the day's work."

There is in some cases a constant yearning for an ever-increasing amount of liquor to produce the original effect. Such a craving is unnatural. No food brings about this ever-increasing desire. If we drink a cup or two of tea for breakfast, we have no wish to drink more, nor does the appetite for tea increase; it never creates a masterly control over our inclinations.

Alcohol lessens the appetite for other food.—One of the chief influences of alcohol is to decrease the waste of the system, and this is in part shown by the lessening of the amount of carbonic acid gas given out by the lungs. Normally our tissues are constantly undergoing change, every tissue and organ is being incessantly broken down and re-built with the materials provided from the food. This process is chiefly one of oxidation. If this oxidation of the tissues or organs is checked, or new tissues are prevented from being formed, the functions of the animal economy cannot be carried out properly. Under alcohol the blood contains less oxygen, but more carbonic acid than normal; therefore the power of using up the food eaten is decreased, and as a result the waste and repair is proportionately lessened. The drunkard, or "tippler" eats less animal and vegetable food, as a rule, than the ordinary man, because to him his alcoholic beverage appears to be a food. This idea is founded on error. The alcohol has in reality lessened his appetite and the functions of the digestive tract. Alcohol contains nothing that can be converted into any tissue of the body. It cannot enter into the construction of brain, nerve, muscle, or blood, although it might interfere with their repair

Large quantities of alcohol (such as are taken during a drunken bout) act upon the brain and spinal cord in such a way that the imbiber cannot any longer control the action of the voluntary muscles. The movements are then disorderly and weak; the person cannot walk steadily; he staggers and reels about. This is the second stage, and is succeeded by a third, in which the mental faculties are so deranged that no reasoning power remains. The speech is then difficult, the voice is thick, husky and broken; all steady, voluntary movement is lost. A fourth stage follows in which the brain is principally involved. We have now an entire depression of the muscular and nervous systems, the imbiber lies like an insensible mass—he is "dead drunk."

Alcohol lessens the power of undergoing severe bodily exertion; it does not impart strength. Those who are going through a system

of training for competitive feats, requiring strength and physical endurance, such as walking, running, rowing, etc., eschew all caloholic liquors, even if they have been previously accustomed to them.

What constitutes excessive use of alcohol.—Experiments have shown that an adult man, in moderate exercise, cannot use up more than 1½ ounces of alcohol within twenty-four hours. When the amount of alcohol is increased to 2 ounces in the day, *excess is reached.* The strength of the body is decreased, nutrition is rendered defective, and such alterations may take place as lead to disease of the lever, lungs, or kidneys. Any amount, therefore, exceeding 1½ ounces of alcohol a day constitutes an excess.

Percentages of alcohol in alcoholic beverages.—The following table shows the relative quantity of absolute alcohol contained in the ordinary fermented drinks of England and the Continent of Europe :—

Drink.	Percentage of absolute alcohol.	Average percentage of absolute alcohol.	Quantity representing about one ounce of absolute alcohol.
Malt Liquors.			
Ale	2·5 to 7 6	5	20 ounces or one imperial pint.
Beer			
Porter			
Stout			
Light Wines.			
Rhine wines ...	6·8 to 12	10	10 ounces or half an imperial pint.
French clarets ...	6·8 ,, 12		
Burgundies... ...	6·0 ,, 13·3		
Rhone	8·5 ,, 13·5		
Strong Wines.			
Madeira	17 to 21	20	5 ounces or 2 ordinary wine-glassfuls.
Port	17 ,, 22		
Sherry	16 ,, 24		
Spirits.			
Gin	40 to 60	50	2 ounces or 1 ordinary wine-glassful.
Whisky	50 ,, 60		
Brandy	53 ,, 60		
Rum	60 ,, 75		

These are approximate quantities only, for the quantity of alcohol in some wines or beers of the same name differ widely.

The maximum quantities that can be taken with any degree of safety are—brandy, whisky, gin or rum 2½ ounces in the 24 hours ; ¾ of a pint of light wines, clarets and hocks ; or 1½ pints of ordinary beer, such as European soldiers use. This represents the quantity which first fails to produce any diminution of physical energy in the adult healthy man. Beyond these quantities it not only does no good, but the excess not utilised as food does harm. It is only exceptionally that alcohol is required as a food. *King's Regulations*, § 27, lays down that 2½ ounces of rum may be issued on field service when ordered by the G. O. C. on the recommendation of the P. M. O. It is highly probable

that the best work of the soldier in the field can be done by total abstinence. The statistical evidence of insurance companies indicates that the best lives are those of total abstainers.

The nutritive value of beer is higher than that of spiritous drinks on account of the dextrine, maltose, and other saccharine bodies in it. On some people beer acts as a depressant, and in excess, it produces stupor and intoxication. In excess it leads to fatness and retards digestion, and produces as much harm as spirit drinking. When taken in strict moderation by those who can stand it at all, it is to some extent invigorating. Men should not drink beer before going to bed, especially in the hot weather. A quart of beer is the maximum that any soldier should take.

Many people consider that small quantities of alcohol, repeatedly taken, act as a stimulant to the brain. Such stimulation is very temporary, and it is now a well-known fact that the highest brain powers are never called forth under the influence of alcoholic stimulants.

Alcohol unnecessary in health.—Alcoholic beverages are unnecessary in health. Some people, however, from delicate constitution, weak digestive organs, or for some other reason, find, by experience, that a small amount of some alcoholic beverage does them good, adds considerably to their comfort, and is necessary to their well-being. In such cases the quantity of the beverage used in the day should not contain more than an ounce and a half of absolute alcohol. The persons who for these reasons enjoy alcoholic beverages most, take them in strictly limited quantities, and usually with their meals, and there is no evidence to show that taken under these conditions, it does any harm to the system.

Excess of alcohol considerably lowers the vitality and healthy state of the body. Such excess is probably one of the greatest predisposing causes of liver abscess, heat syncope and heat apoplexy, dysentery, infective diarrhœa, and infectious disease generally. With such excess the gates for the access of disease-germs are always open.

When $\frac{1}{80}$th part of the body-weight of alcohol is taken, only 3 per cent. appears in the urine and breath; the rest is used as a food. If double this quantity is taken 10 per cent. appears in the urine and breath; if $\frac{1}{300}$th is taken then 50 per cent. appears, and if a larger amount then 75 per cent. or more. In other words when small doses are taken it is capable of being used as a food; when large doses are taken only half is so used, and when very large only a quarter.

Bazaar liquors are as a rule highly injurious, and should never be used. They often contain harmful agents and frequently the alcohol in them is not sufficiently matured.

It is sound rule never to take alcohol in any form until the sun goes down. This is a rule observed by most experienced officers of the Army in India.

Alcohol should never be taken on an empty stomach. Its best effects are secured when it is taken with the food, especially with a late dinner. The use of alcohol during the middle of the day is to be discouraged in this country. The use of alcohol during duty should be strictly forbidden. Within the limits stated it can do little harm when taken after the day's work is over.

We cannot in the light of present-day knowledge and experience condemn alcohol as an article that is always injurious. It is certainly useful in some diseased conditions, and is sometimes desirable in health.

Service in the Army, as in most other callings, has its little cares and worries, and it is probable that, with some men, a small or moderate amount of alcohol taken with a meal after the day's work is over, may soothe the system, prevent waste of tissue, stimulate flagging energies, and help digestion. In the case of senior officers who have served many years in India, alcohol in small quantities is often a useful addition to the diet.

When men are known to be inclined to abuse the use of alcohol, we should encourage and help them to become total abstainers. If men merely take alcohol within the limits stated above we are scarcely justified, in the present state of our knowledge regarding alcohol, in coercing them to total abstinence.

These are the main considerations that should guide our views in regard to the use of alcohol in the Army—they are unassociated with the extreme opinions of rabid supporters of teetotalism, they emphatically discountenance the abuse of alcohol, and give a freedom of action to those who can adhere strictly to moderation.

Men have been capable of the greatest bodily and mental exertion without alcohol, and in extremes of heat and cold they are undoubtedly better without it, provided that in the latter case, at least, they have appropriate food.

Alcohol in disease.—Most people admit that alcohol is a valuable drug, and those who have had to deal much with the abnormal conditions of the human economy, know of what immense value it is in many cases. We fully recognise the usefulness of alcohol in certain cases of weak digestion. St. Paul advised Timothy to abstain from water, and "take a little wine for his stomach's sake and his often infirmities." In the convalescent, in the weak, and the aged, we frequently find that a little alcohol with the food is very serviceable. In some cases of weak heart, in fainting from shocks of every kind, and where there is want of general tone in the body, alcohol seems to effect an improvement which no other medicine can. It is a powerful remedy in some fevers, especially in the later stages, when it reduces the temperature and calms the delirious brain.

Whilst alcohol may be used with great benefit, and in very large doses in some few cases of disease, the knowledge of how and when to use it with profit is one of the points which requires all the special skill and experience of the physician, and the indications for its judicious use require technical knowledge which can not be imparted by words. It is especially in the later stages of acute diseases and fevers, and in some diseases of the nervous system and heart, that it finds its greatest use ; but in such cases it is always prescribed as a medicine, in carefully measured doses, and at stated hours, and this is never left to the discretion either of the nurse or the patient. Let it not be imagined that caprice, or educational bias, guides the doctor in giving, or withholding alcohol in disease. There is no drug the effects of which in abnormal conditions of the human economy has been more minutely, thoroughly, and scientifically investigated of late years than alcohol, and a great mass of accurate knowledge as to its effects is the result ; so that he who states that the giving of alcohol is merely a matter of routine practice on the part of physicians, entirely misinterprets the position and responsibilities of medical men.

Saké was issued to the Japanese during the late war. They were strictly prohibited from buying alcoholic drink of any kind from villages, but were permitted to do so from military canteens, which the medical authorities examined at least twice a month.

M.—Use of Tobacco.

Tobacco is generally used for smoking, less frequently for chewing and as a snuff. Whilst one would not say that tobacco is a necessity to the soldier, either in garrison or in the field, there is a general concensus of opinion among military medical officers that its moderate use adds considerably to the comfort and happiness of those who indulge in it. The tobacco-smoker, when deprived of his pipe or other form of smoke, often feels the want of it more than he does of food. In moderation, after meals, tobacco-smoking stimulates gastric secretion, aids digestion, and increases the action of the bowels by stimulating the contraction of the involuntary muscular coats of the large bowel (stimulating peristalsis), and where the supply of food is deficient it diminishes the sensation of hunger. "Korloff during the Russo-Turkish War of 1878, studied its properties minutely in regard to blunting the sense of hunger, and as a result he recommended that a daily ration of tobacco be issued to the Russian troops." In the Armies of the United States and Germany tobacco is one of the components of the emergency and ordinary ration respectively on field service.

When not to smoke.—Smoking during the heat of the day, particularly while on the march, increases thirst and leads to unnecessary drinking. The same result follows the chewing of tobacco on the march, due to the loss of salivary fluids caused by frequent spitting. Tobacco may be used to overcome weariness ; it serves to relieve *ennui*,

and on many of its habitués has a very soothing effect. We know that in standing camps, during periods of inactivity and inertia, the monotony of life sooner or later jars and frets the soldier ; during these periods tobacco is used nominally to pass the time ; but in reality as a calmative on the unemployed nervous system. Under such circumstance there is the risk of its being used to excess and of its producing harmful effects, and men should be cautioned about this.

What constitutes excessive use.—It has been estimated that in pipe-smoking the average consumption is something over half an ounce of tobacco a day, and that an ounce *per diem* is excessive. It is scarcely possible to state the minimum quantity that would be harmful to any one individual, but the occurrence of shortness of breath, palpitation, obscure pains about the region of the heart, nervous irritability with loss of appetite, are indications to reduce or temporarily abstain from the use of tobacco. More pronounced symptoms resulting from its use are loss of appetite, impaired muscular energy, giddiness, alteration of vision, loss of memory, and progressive general weakness.

Moderate use practically never harmful.—One has no hesitation in saying that tobacco is only harmful to fully trained soldiers with a highly neurotic tendency, and to those of insufficient will-power to properly regulate and restrict its use. Whatever be the possible theoretical risks associated with its use, the records of our hospitals, either in peace or war, do not show that tobacco-smoking is in any sense a serious cause of inefficiency or danger.

The amount of nicotine in tobacco smoke cannot be definitely stated as it varies with the kind of tobacco and the way in which it is inhaled, but only a small proportion of that contained in the tobacco passes over in the smoke. In snuff there is generally only a small amount of nicotine, while in chewing tobacco there is generally a varying amount of foreign matter such as molasses.

The enjoyment of tobacco-smoking has never been satisfactorily explained, and it is not even proved that nicotine is essential to the pleasurable results. The outcome of a vast amount of experimentation in connection with tobacco-smoking is that so far its effects are unexplained.

One point appears to be quite certain—the tobacco habit cannot be compared with the use of such drugs as opium, morphine, cocaine or alcohol, as it is not taken for the purpose of producing stimulation or depression of the central nervous sytsem, and it would appear doubtful whether the amount of nicotine absorbed has any action at all.

It is a curious fact that with many smokers, the pleasure of smoking is largely abolished when smoking in the dark, or in a stormy wind, and when the smoke is not seen.

One of the commonest effects of over-indulgence in tobacco is a chronic inflammation of the throat and upper parts of the respiratory passages, leading to hoarseness and excessive secretion of mucus from the mucous glands of these regions. This is explained by the constant

action of an irritant alkaline vapour and pyridine (a body having the peculiar smell of burnt matter, and is combined with the nicotine), and is not due to the nicotine. A similar irritated condition of the tongue is frequently met with, especially when the hot vapour is directed on one part, as in pipe-smoking, and it is sometimes stated that the constant irritation thus produced render the tongue and lips more liable to cancer in these parts.

Dyspepsia, loss of appetite, and consequent loss of flesh may also be explained by the local irritation produced by the swallowed saliva. In the great majority of cases of chronic tobacco poisoning, the symptoms disappear on relinquishing the habit or even restricting the daily consumption.

The most wholesome form of tobacco-smoking is probably that of a pipe and next that of a cigar. Cigarette smoking is the most injurious, chiefly because the ordinary cigarette smoker inhales all the fumes which tend to irritate the throat and upper part of the air passages, etc.

The practice of cigarette smoking has rapidly extended in this country and is doing a considerable amount of harm to the male part of the youthful population. Smoking of the *hookah*, in which the fumes first pass through a bowl of water below the *chilum*, when the tobacco is pure, is probably one of the cleanest and most innocent forms of tobacco-smoking indulged in.

Moderate tobacco-smoking by fully developed and fully trained soldiers does no harm. It allays the feeling of hunger, in some unknown way soothes the system, and adds to personal comfort. When used in excess it is always injurious, as it is in untrained youths whose hearts are inordinately susceptible to its effects. The cigarettes now largely imported into this country and used by our troops, made from the most villainous refuse tobacco in the market, are injurious. Last year one saw largely advertised a brand of cigarettes sold at 20 for 6 pies, in which the tobacco was uncured and half rotten. The form of cigarette smoking that has sprung up in the Army in recent years should be discouraged in every possible way—it can do nothing but harm. The most injurious part of this habit is inhaling the smoke. The tobacco sold in cantonments, canteens and coffee-shops should be closely watched and controlled.

Tobacco chewing should be discouraged in the Army—tobacco affects the system more directly when chewed ; it leads to excessive spitting and subsequent thirst.

The use of the strong twist or roll tobacco for the pipe should also be discouraged, it often disturbs the action of the heart in even the most hardened smokers.

The best time for smoking is after meals—it is then better enjoyed and has least injurious effects. Smoking during the actual hours of duty and on fatigue should be forbidden. It is better not to smoke just before commencing any work requiring much physical exertion.

Various orders regarding cigarette smoking have appeared, issued usually by commanding officers and general officers on their own responsibility, from time to time, and from these one would abstract the following two. The first is with reference the troops in the Irish Command:—

"The Commander of the forces has during recent visits to Military Hospitals been again struck by the harm that the increasing prevalence of cigarette smoking is doing to the health of the Army. It is not confined to the Army, and Parliament is likely soon to deal with it as affecting the national health. Lord Grenfell appeals to the Irish Command to give earnest and early thought to combat what is gradually but greatly, affecting its efficiency, and he requires all Commanding Officers to impress on those under their command the evils that inevitably result from this excess. He would point out that in other directions the health and well-being of the troops in this command have greatly benefitted from the loyal and intelligent co-operation of all ranks in giving effect to sanitary measures suggested by the medical authorities. He looks forward with confidence to a similar appreciation of his endeavour to mitigate the harm done by excessive cigarette smoking, especially among the younger soldiers.

"With a view to helping men to overcome the habit, the commander of the forces directs the smoking of cigarettes to be prohibited at certain times when, on the other hand, no similar restriction as regards pipe-smoking will be made. The smoking of cigarettes, therefore, will not be permitted when men are on fatigue or under arms on any occasion, including field operations and manœuvres."

The following was published by the officer commanding a British unit:—

"It has been brought to the notice of the Commanding Officer by the Medical Officer and from other sources that a considerable amount of harm to the health of the battalion is being done by the very large amount of cigarettes that are being smoked by all ranks. The following order will be strictly adhered to from this date.

"Cigarettes will never be smoked by any officer, warrant officer, non-commissioned officer or man, when on any duty whatsoever, that is, when on manœuvres, field days, route marches, company parades, guard duties and fatigues, or when employed in any of the regimental institutes or any of the battalion offices, or when attending such offices."

It is an unfortunate circumstance that the habit of cigarette smoking has grown very considerabely both amongst our European and Native troops in India. All boys in the service should be strictly forbidden from smoking cigarettes.

The habit of passing the pipe from mouth to mouth should be stopped—disease is occasionally communicated in this way.

It is highly probable that both European and Native soldiers smoke more than the civilian classes from whom they are drawn, for they have on an average more money to spend and more time to spare. When the civilian is going in for a competition in running, walking, rowing, etc., he puts himself through a course of exercise and either entirely relinquishes or greatly reduces his smoking.

Chewing of kola nut and cocaine leaves.—One is strongly opposed to the use of such artificial aids to endurance as the *kola* nut (even when obtainable in the fresh state when its reputed virtues are at their highest), chewing of coca leaves as used by the Peruvian post messengers and labourers, etc., which are said to banish hunger, thirst, and all sense of fatigue. One recalls an article written many years ago in, as far as one can remember, the *Nineteenth Century*, in which it was seriously proposed to supply all men with coca leaves (leaves of the *Erythroxylon coca*) as a part of their emergency ration, these leaves to be placed inside the flap of the blouse in the same way as our troops carry the first field dressing!

BARRACKS AND THEIR SANITATION.

A.—Barracks for European troops.

Remarks on Site and Construction.

Defectively constructed barracks have given rise to a considerable amount of disease in our Army in the past, and in some European Armies are still responsible for a fair amount of sickness and inefficiency. In the past the chief defects in barracks were—overcrowding, deficient cubic and superficial space, and inadequate arrangements for ventilation. None of these conditions exist in our European troops' barracks of the present day in India and in only comparatively few cases can they be said to exist in the barracks of Native troops.

In many of the older European soliders' barracks, the barrack-room was used for various purposes—as a sleeping room, living and dining room, which arrangement was decidedly unwholesome. In practically all barracks now there are verandahs in which the men take their meals or special dining halls, which have added much to the men's comfort.

Conditions necessary for thoroughly Sanitary and Healthy Barracks.—The main points in connection with sanitary and healthy barracks are that they should be in a dry site, and have an aspect that gives light and cheerfulness; that they are provided with a supply of wholesome water, with means to remove waste water by which perfect cleanliness of all parts of the barracks can be ensured; have a system of conservancy that gets rid of all human excreta in such a way that reduces to a minimum the possibility of contamination of air, water

and food ; a system of ventilation which carries off all aerial impurities and a state of construction which ensures perfect dryness of foundations, walls, and roofs.

Site for barracks.—When there is a choice of sites, the special points to attend to are—the nature of the surface soil and subsoil, the ordinary level of the ground water, the conditions as to natural drainage and facilities for artficial drainage ; the configuration of the locality as to whether it is elevated, flat, undulating, or depressed, the aspect, extent of exposure to heat or cold, surroundings, purity of air, and nearness to open collections of water.

The site should be open, freely exposed to the air on all sides, fairly elevated and with a moderate sprinkling of trees. There should be a certain amount of slope, preferably all round, to facilitate drainage with natural drainage channels or outlets. The soil should be dry and of a porous nature, gravel being the best ; sand and sandstone are good ; chalk and chalkstone are also good soils but seldom available in this country. Alluvial soils, clay soils, marls and loams are unhealthy, and, if they must be used, should be previously thoroughly drained. A thin stratum of sand or gravel resting upon clay is a most unhealthy site. "Made soils" and reclaimed land are unhealthy.

A *coarse gravel* or sandy soil is healthy if it drains itself thoroughly, and provided it does not rest on a bed of clay that is close to the surface. A gravelly porous soil is on the whole the healthiest to build on. A gravelly soil contains about one-third of its bulk of air and a quantityof water which varies with the subsoil drainage and rainfall, and the proportion of subsoil water in the locality.

Alluvial soils are insalubrious sites as they are usually damp (the subsoil water being close to the surface), and they contain an abundance of organic matter that has been brought down by rivers.

Clay soils should be avoided as they are associated with a high subsoil water level, collections of surface water, and mosquitoes, and, through these latter, with malaria.

Valleys and craters between hills are always hot and unhealthy from the absence of free ventilation and dampness of the soil. Ravines are always in the line of the natural outflow of subterranean water, and are therefore usually damp and unhealthy. A site near stagnant water which cannot be removed should be avoided.

It should be remembered that the soil on which we build is not a solid mass—it is porous, and its pores, or the spaces between the solid particles of the soil are filled with water or air, usually both, the amount of each varying. The air is constantly rising, falling, and moving laterally in the ventilation of the soil, and the water is always moving towards the outlet for the subsoil water, or towards other bodies of water such as wells, which then intercept its flow towards such outlet.

Hence such wells if shallow (and even deep wells if not properly steined) will be polluted by any impurities brought by the water from the surface soil and subsoil. It should be remembered that the walls of barracks stand on earth, air and water, and not on earth only.

European troops' barracks adjacent to Native bazaars are practically always unhealthy. The children of native quarters are often infected with malaria, and anophelines are invariably present during the malaria season. The surroundings of the ordinary bazaar and native quarters are usually insanitary. All barracks should be situated at a distance of at least half a mile from bazaars and towns.

Drainage of damp sites.—Wherever any question of dampness of the site arises, the area should be thoroughly drained before being built on. This may be done in various ways, *e.g.*, laying unjointed stout glazed earthenware pipes in the lines of natural drainage and covering them up; or by simply laying boulders of stone in similar lines beneath the surface. In all such cases the barracks must be shut off from the subsoil by solid impermeable foundations (with a damp-proof course in the walls) and be erected on a plinth which should never be less than 2 feet in height.

One of the most important points is that the ground water should not only be deep, but also of fairly uniform level. An oscillating subsoil water level is intimately connected with the prevalence of several diseases.

Other considerations in connection with sites are referred to under *Sanitation of Camps.*

In all cases it is essential to select a site that is free from large natural or artificial collections of water within a radius of half a mile, or when these exist they should be capable of being readily filled up or drained.

In the case of all new barracks the bearings of the site chosen on the health of troops is now deliberated on, and all hygienic conditions thoroughly considered before the site is finally decided upon. An excess of trees is undesirable, they give shelter to mosquitoes. There is a mistaken notion that trees give coolness to barracks and bungalows; they do not do so unless there is a regular forest of them, or unless they are right against a barrack, in which case they close out air and light and bring mosquitoes right up to the doors and windows.

Direction of barracks.—The direction of the long axis of barrack rooms should be east and west. This prevents the sun beating into the barrack rooms during the mornings and afternoons, and at the same time allows of perflation of air by means of the two chief winds of this country (which blow south-west and north-east) at such an angle as to permit of complete diffusion without merely passing

through. This aspect also gives the best kind of natural light. The next best direction for the long axis of barracks is north-west and south-east.

A common arrangement of regimental barracks for European troops is a long line or double line of buildings, *en echelon*, which are either double or single-storied, with through cross ventilation, and high plinths. Practically all the newer barracks in India are single-storied.

The materials used in the construction of barracks should be such as will not harbour insects, vermin, or reptiles of any sort. One of the main objects to be aimed at in the construction of modern barracks is the maintenance of a state of perfect cleanliness with the greatest facility and the least expenditure of manual labour.

No earth for the construction of any part of barracks should be taken from the immediate neighbourhood of the buildings. In the building of barracks no borrow-pits should be created. All earth required for building purposes should be obtained from sites at a distance from the cantonment, and the sites for this purpose should be fixed by the cantonment authority.

Authorised accommodation for European troops on the plains—The authorised accommodation for European troops in barrack rooms (dormitories) on the plains is 1,440 cubic feet of air space and 90 square feet of floor area per man; in day-rooms it is 20 square feet of floor area. Dormitories should usually be 24 feet wide so as to allow of two rows of beds only, and 16 feet high to the beam. Each dormitory should accommodate not less than 16 and not more than 24 men. Two beds only are to be placed between adjoining doors, with 9 inches clear between each bed and the door. Verandahs are to be 10 feet wide in the clear; the verandah supports should be posts of wood or stone. All buildings occupied by British troops in the plains are to have double roof coverings or ceilings under a single roof.

Authorised accommodation for European troops on the hills.—The hill type of hut or barrack is divided into bays, each consisting of 6 running feet of a building 20 feet broad, with a 9-foot verandah in front. Each bay provides accommodation for two men, giving 60 square feet of floor area and 600 cubic feet of air space per man. Dining or day-room space is provided, either by additional bays in prolongation of the dormitories, with or without partitions between, on the scale of 2 bays for 12 to 18 men; or, by enclosing the verandahs, which thus form the dining rooms for the men accommodated in the corresponding bays under the main roof. The local military authorities decide which style of hut is to be adopted. The size of the huts or barracks will depend on the sites available, but they should be built to house a whole, half, or a quarter company each.*

* A. R. I., Vol. XII, pp. 29-30

The entire barrack should be arranged so as to facilitate freedom of surface drainage and ventilation, and there should be some approach to uniformity. The individual barracks should not be closer to one another than twice the height from the eaves to the ground.

Foundation.—It is always necessary to have a solid impermeable foundation consisting of concrete or other water-tight material *below the surface* (to keep out ground water and impure air) and *a plinth* above, and the latter should be at least a few feet high. These are indispensable where the subsoil water is near the surface. Raising barracks on arches, pillars, or columns, in addition to an impermeable foundation, keeps out subsoil water more thoroughly.

The foundation should be followed by the basement walls constructed in trenches below the surface; next the *plinth* should extend over the whole area to be occupied by the barrack, and to a little distance beyond the lines of the house walls on all four sides, and on the sides where the verandahs are to be constructed the plinth is to extend for the whole width of the verandahs. The plinth may be of stone or brick throughout, or it may be arranged in arches or low separate columns with spaces between, on which the stone or brick or other floor is to be supported.

The *floors* should always be constructed of some impermeable material, and should slope slightly towards the drainage outlet.

In general the best flooring is flags, next tiles, glazed bricks on edge, or cement. In such floorings vermin and insects do not collect. Wooden floors are to be avoided—they are attacked by insects and decay, and beneath them all forms of vegetable and animal life often thrive.

Damp-proof course.—From what has been stated it will be seen that unless a barrack is shut off from the subsoil water by an impermeable foundation and a damp-proof course, the subsoil water is sucked into the walls of the barrack, and the walls are made damp and unhealthy because they predispose to chills, as the heat of our bodies is abstracted to evaporate the moisture from the inner surface of the walls. Damp walls also interfere with ventilation by the water preventing the passage of air through the walls. Damp walls may to some extent be dried by opening all doors and windows and lighting fires in rooms, but when a barrack is unprotected from the subsoil water such measures are only of temporary use.

Similarly in the absence of a damp-proof course and impermeable foundation, if the subsoil is dry, the porous structure of the walls permits of subsoil air being sucked into houses, as the air of houses is usually warmer than that of the subsoil. This ground air is very impure; it contains a large amount of carbon dioxide—an amount varying from 100 to 400 times more than ordinary air. By adjusting two rubber tubes at the diagonal corners of a brick we can blow out a candle from one tube to the other, or by putting one of the ends of an unglazed

brick into water the whole brick sucks up water by capillary attraction on account of its porous nature, these pores in the dry state being filled with air. An ordinary brick $9\frac{1}{2}'' \times 3\frac{1}{2}'' \times 2\frac{1}{4}''$ holds 16 ounces of water. Hence unless a barrack constructed of brick is shut off from the subsoil water by an impermeable foundation and a damp-proof course, the subsoil water is sucked into the walls of the barrack.

All well made houses are provided with a damp-proof course through the middle or lower part of the plinth and along the walls above their junction with the surface. Various forms of damp-proof courses are used—perforated hard glazed brick, or slate ; or a layer of two inches of slaked lime thoroughly mixed with some vegetable oil is spread over the foundation below the plinth allowing this to set for a few days, the bricks or stones of the plinth being afterwards carefully and evenly laid upon it, care being taken not to crack or break it. Any good impermeable building material may be used for this—even tarred bricks, the bricks being heated to redness, thrown into boiling tar, and rolled in dry sand.

The walls of a barrack should not be too thick ; thick walls make the building hot by day and it does not cool rapidly at night.

The direct sun heat has to be excluded from barracks, as apart from the effects of its heat on the occupants, it tends to destroy furniture —it cracks, splits and warps all wooden articles and blisters varnished ones.

Roof.—The roof should be substantially built. The coolest and probably the best roof is made double and sloping. For this purpose we may use double layers of tiles. When double tiles are used they should be laid on wood. If corrugated iron is used for building barracks or huts, it should be close-boarded beneath or lined with some form of thick felt, both as to roof and walls. Corrugated iron alone, whether for the entire barrack or hut, or the roof, is intensely hot in the summer and cold in the winter.

Roofs with a ceiling cloth beneath are abominations that should be condemned. Usually, however, the best material available in the locality is used, and can, as a rule, be adopted to carrying out the principles laid down in the foregoing remarks.

The eaves of the roof should extend well outside the walls to permit of rain-water falling free of all parts of the building on to the paved or impermeable area below. The verandah roofs (if these are separate from the general roof) should also be provided with arrangements to carry off rain-water free of the plinth below. All barracks should have arrangements for carrying off the rain-water from roofs into the barrack drains. In new barracks all doors and windows should be provided with mosquito-proof wire-gauze set in the framework. In barracks already constructed it is also desirable to provide mosquito-proof wire-gauze doors and windows. This may consist of brass, copper or tinned wire of at least 16 strands to the square inch. All verandahs might with advantage be protected with wire-gauze in the same way.

Thatch roofs were to some extent used in barracks many years ago and are very common in private bungalows in cantonments still. These roofs consist of a bamboo framework upon which is laid a thatching of long grass, palm leaves or other material. They are cooler than most other roofs They, however, require to be removed every two years or so, as the thatch rots; they are highly inflammable, harbour snakes, rats and other vermin, and are a favourite place for birds to roost in. They are very popular with mosquitoes, both during the breeding season and when these insects are hibernating and estivating.

Verandahs.—Every well made barrack in India should have a verandah either all round or at least on two or three sides. This is necessary to protect the interior of the barrack from the sun and the walls from driving rain, and for general convenience. When verandahs are on three sides the north one should be free. The pillars supporting the verandah should be light in structure and ascend from the plinth; the plinth and verandah are thus not affected by the sun or by rainfall. Verandah roofs should be as high as compatible with the structure of the barrack; they should not slope excessively as this would exclude sunlight from the rooms; yet they should not be too horizontal or this would allow a hot sun to beat in on the verandah for several hours each day. When only one side of the barrack can be provided with a verandah, this should be constructed in front, and formed of a raised plinth, which should, if possible, be properly flagged or paved This gives the space of, and serves as an additional room to work in, and is an excellent provision by permitting the due airing and ventilation of the other rooms. The roof of the verandah should be a few feet below the main roof of the building, and it is well to provide one or more small windows in the intervals in the wall between the two roofs.

The barrack rooms require to be much higher than in temperate climates to keep down the heat, as the heat given off from the roof is in inverse ratio to its height from the occupants. The average height recommended is 16 feet. If it is higher than this then beams have to be specially constructed across the rooms for the suspension of punkahs where electric fans are not in use.

The outer walls of barrack rooms should be shielded, as far as practicable, from the direct rays of the sun by deep and high verandahs. If this is not done and the verandah is low, the higher part of the wall gets very hot and gives off its heat to the air of the room within. One of the main functions of the verandah is to protect the outer walls from the heat. If they run right up to the eaves then there should be some form of roof ventilation. Verandahs should be at least 10 feet wide and even wider if practicable, 15 feet being a fair and effective width.

The usual arrangements for ventilating the barracks of troops are doors and windows; in hill stations, and in Northern India on the plains there are also, in many stations, fireplaces. In a few cases there

are special ventilators let into the walls, and in some also there is ridge or eaves ventilation. All barracks should have windows at the tops of the rooms to get rid of foul air. These should be as near the top of the outer walls as possible, otherwise there is a layer of stagnant foul air above, which, when the room cools, descends. In the absence of these high windows there should be ridge or other form of roof ventilation. Practically all European soldiers' barracks in India are now so constructed that there should be no difficulty in connection with ventilation if the doors and windows are adjusted properly. In many of our Native troops' barracks, however, the ventilation is decidedly defective, and the cause of this is generally the absence of windows. For the same reason the barrack rooms are in many stations dark during the day. The artificial lighting at night is defective.

As a rule air that has been expired and warmed rises to the higher parts of rooms and leaves by any outlets there, and fresh air enters by the lower openings. If the doors and windows of barrack rooms and the upper skylights are kept open, this is what usually occurs. The windows and doors of every barrack room should communicate with the external air. The large numbers of doors and windows to Indian barrack rooms render any accessories to ventilation unnecessary. There is a rooted prejudice amongst some soldiers, especially Native soldiers, against so-called draughts, and this is responsible for much of the aerial impurity of barrack rooms.

The lighting of the soldiers' barrack is capable of some improvement, although the question is difficult in the almost universal absence of both gas and electric lighting.

There are many types of barracks in existence in India varying from a large double-storied block intended to accommodate a whole battalion, such as the Dalhousie Barracks in Fort William, Calcutta, to single-storied buildings to hold one company or half a company.

Whilst the older pattern barracks have their defects much may be done with our present-day sanitary appliances and organisation to make them healthy dwelling places for our soldiers.

B.—Sanitation of Barracks.

(a) European Troops.

There are various matters intimately connected with the life of the soldier in barracks which may be considered to be quite personal to him, but which also require the attention and control of section commanders and company commanders. These matters specially refer to the cleanliness of the barrack room, the personal habits of the men, exposure of the bedding and clothes to the sun and air periodically, proper use of wash-houses, proper use and care of latrines and urinals, etc.

Barrack-rooms.—The main sources of contamination of air in barracks are—the products of respiration, combustion, decomposition and dust. Such diseases as tuberculosis of the lungs, pneumonia, and sorethroat, due to special germs, are liable to be communicated through the air of barrack-rooms from infected men to the healthy when ventilation is defective, and especially when the superficial area per man is restricted and the men brought closer together. There is a certain amount of dirt being constantly brought on the boots of the men, of hawkers, and of hangers on. These latter should as far as practicable be excluded from barracks.

The best test as to the purity of the air in a barrack room or tent is the feeling of freshness in the room on first entering it from the outside air; this test is best applied after all the men have been in bed some time. Any appreciable difference or stuffiness indicates defective ventilation (see p. 156).

White-washing.—The interior of the barrack-room walls is white-washed* twice a year, and every four years the woodwork is painted. White-washing acts as a mild disinfectant and helps to ward off mosquitoes. Before repeating the white-washing the old lime coating should be scraped off, and the walls thoroughly washed and allowed to dry. White-washing is a valuable means of removing dirt, dust, and germs from walls. When an infectious disease breaks out epidemically in a barrack-room, the walls of the room should be thoroughly scraped and white-washed before re-occupation.

For the outside of the barrack a colour-wash of cream or grey is preferable, for although white-wash is cooler by reason of reflecting back practically all the heat rays of the sun to the air, it is very trying to the eyes on account of the glare from it.

As most barracks have stone floors, there should be no difficulty in keeping them thoroughly clean without deluging them with water. In sweeping the barrack room, moist, used tea leaves, or green leaves of any kind, help to keep down dust. Where there are boarded floors, as in the barracks of some hill stations for European and Gurkha troops, the water used for washing floors passes between the boards and keeps the room damp; it mixes with the dirt, dust and microbes gathered beneath, and helps the multiplication of the latter.

"If the floor is hard and smooth dry scrubbing will suffice to keep it clean, but it will usually be necessary to wash the barrack floor once a week. In doing this only sufficient water should be used to scrub the floor and clean off the soap, and all excess of water should be mopped up as the scrubbing proceeds." Washing of barrack-room floors with large volumes of water is unnecessary and unhealthy. There is no reason why the barrack room in India should not be scrubbed down by the men in the same way as is done in the home barracks.

* *White-wash* is prepared by mixing ordinary lime (oxide of calcium) with water until the mixture has a thin creamy consistence.

The washing should be done in the morning when the men are usually out, to allow of the drying of the room before bed time, and doors and windows must be left open to hasten drying. It is advisable to avoid washing floors in wet weather.

Walls, which usually contain dust and dirt, including disease-germs, should be wiped with a wet cloth.

Mops, scrubbing brushes, brooms, dust-pans, and pails used for cleaning the barracks should be kept in a cupboard in the verandah. The practice of sweepers entering barrack rooms and using a broom for sweeping the floor is objectionable. The same broom may have been used in the latrines. All the cleaning up that is necessary in a barrack room should be done by the soldier himself, and this applies to both the European and Native barracks. The same remark holds good for officers' bungalows, in which the sweeper uses his broom for everything—the house, carpets, dining room, the kitchen, stable, the compound and the latrine; it should be done by some other servant. The practice of sweepers cleaning rooms cannot be too strongly condemned.

The floors of all coffee-shops, canteens, Army Temperance Association rooms, and all regimental institutes visited by soldiers, should be broomed or brushed daily by soldiers. In doing this the floor might be first covered with moist, used tea leaves, or green leaves of any sort; it should seldom be necessary to actually sprinkle the floors with water, but if water has to be used, it should be sterilised.

The tables off which the men eat should be kept scrupulously clean. The use of table-cloths greatly facilitates this. Plates and dishes should be supplied in sufficient numbers.

Food should never be stored in barrack rooms. It is often kept on shelves, in kit boxes, under the beds, and in other places exposed to dust and flies. "Every dining room should have suitably designed lockers or safes in which men could reserve or keep back uneaten food with some reasonable chance of its remaining sweet and clean." Cupboards inside barrack rooms should never be repositories for food as this attracts flies.

The arrangements for washing up during and after meals are important. "In all cases the sanitary orderly of the company, under the section commander, should superintend the washing up after every meal and be responsible to him." All cans, dishes, plates, mugs, knives and forks, tubs and other utensils used at meal times, or for food storage, should be scoured and cleaned on the scullery table of the company, battery or squadron, and not placed on the floor or taken to outside taps. A large tin or bath, especially marked "dishes" should be

provided for the washing up of such utensils and used for no other purpose. Clean cloths only should be employed for washing utensils in the bath, which must be well supplied with hot water from the cook-house.

All the cloths used for this purpose should be washed daily and hung to dry on the scullery table, each cloth being marked "dish-cloth" in large letters. For the scouring of tea-cans, meat dishes, knives and forks. clean bath-brick shaken from a perforated tin kept for the purpose should only be used. The use of casually collected sand for this purpose must be forbidden. The scullery-table should be inspected daily by the orderly officer, and the dining-room should be provided with a conveniently placed sink with hot and cold water. The carrying out of these details will be facilitated by the issue of an *order board*, signed by the Adjutant, to the sanitary orderly of the company, squadron, or battery, whose especial duty should be to superintend the cleaning by cleanly means of everything used by the men at their meals.

There should be systematic arrangements for washing up in all dining halls and verandahs used for dining in. The following is carried out in Cairo by all troops in the command :—

The Order Board reads as follows :—

INSTRUCTIONS FOR THE SANITARY ORDERLY SUPERINTENDING THE WASHING-UP OF DISHES AFTER MEALS.

(1) All cans, meat dishes, plates, mugs, knives and forks, bath tins, and other utensils used at meal times, should be *scoured or cleaned on the scullery table of the company on the verandah or in the barrack room*, and *not placed on the floor or taken to outside taps.*

(2) *One bath*, marked "Dishes," and *one ration tin should be used in the washing-up of such utensils.* They should be *filled with boiled water from the cook-house.* After a meal the utensils should be first washed in the bath and *then passed through the water of the ration tin containing half a teaspoonful of permanganate of potash dissolved in it.*

(3) *Washing baths for dishes should on no account be used for other purposes.*

(4) Clean *sponge cloths* only should be employed for *washing utensils in the bath*, and they should be well washed in clean water before drying. These sponge cloths with the *drying cloths should be hung to dry on the scullery table.*

(5) *Only clean bath-brick, shaken from a tin (coffee tin with perforated lid or such-like)*, should be used for scouring tea cans, meat dishes, and knives and forks.

(6) The *sanitary orderly of the company*, under the non-commissioned officer of the room, should superintend the washing-up after every meal and be responsible to him.

The reason for having a scullery table is that everything used by the men at their meals and for carrying their food to them *should be cleaned by cleanly means on a table and away from the floor or the ground.**

All men, both European and Native, should invariably wash their hands before taking their meals.

In the most approved barracks of the present day, such as those in Quetta and other stations, there are separate dining halls connected with the main barracks by means of a covered way.

Bedding.—All the bedding should be taken out into the open, thoroughly shaken, aired and sunned for at least two hours every week. It is not generally known that about 8 per cent. of the men wet their bedding at night at least once a month. If bed sheets are used they should be changed at least once a fortnight.

Each man should invariably use his own bedding and towel. Whenever the bedding is infected by disease-germs, it should be thoroughly disinfected at the hospital. European troops should be prevented from using their blankets as a carpet. The blanket collects germs from the boots, which, when the blanket is used in the bed, opens the way to infection by disease-germs.

The bed cots should also be cleaned outside the barrack and allowed to remain in the sun for a few hours once a week. Bugs adhere to the chinks in furniture, bed cots, in the bedding, between the wall and the white-wash, and are sometimes difficult to eradicate. Soaking of the furniture and bed cot in kerosine oil kills the bugs and prevents the eggs from hatching. Blankets may be disinfected by heat. Thorough cleanliness prevents the occurrence of such vermin as lice, fleas, and bugs.

The bedding of all men who go to hospital should be kept separate in the company or double company store room. This prevents the blankets of a possibly infected man being mixed up with those of other men. All blankets should bear the regimental number by which it can be at once known. The bedding, kit, and feeding utensils of all men who go to hospital for infective disease should be sent to the hospital for disinfection. When this is carried out they will be returned to the company or double company stores. As soon as such a case comes to hospital, or is diagnosed, the medical officer in charge should send for these articles, and the company commander or some non-commissioned officer deputed by him should see that the particular

* Major I. R. BLACKHAM, R.A.M.C., *Military Sanitation*, p. 78.

man's bedding is sent. This is a matter of considerable importance in connection with such infectious diseases as typhoid fever, dysentery, infective diarrhœa, tuberculosis, syphilis, ophthalmia, and certain skin diseases, such as scabies (itch) and ringworm.

The heads of the beds should not be nearer than 12 inches from the walls, and at least a yard should exist between each bed. This permits of a current of air all around the bed, accessibility to the wall and floor at the head of the bed for cleaning, and prevents close aggregation of the men when sleeping.

When weather permits windows and doors should be kept wide open all day and night. All the light and air available should be allowed to enter barrack rooms. There are only a few months of the hot weather in which this rule cannot be adopted, but even then the doors should be closed as late in the morning and as early in the afternoon as the heat of the weather permits.

Dogs and other domestic pets should not be kept in barrack-rooms.*

Punkahs.— *Punkahs* assist ventilation and add to comfort, for they help to distribute the air, create currents, facilitate evaporation of moisture from the surface of the body, and the air currents increase the speed of radiation of heat from the body. When the air is still and hot ventilation is very slow. It is, however, risky to come into rooms with punkahs and tatties when perspiring and feeling hot, for the body will then cool down rapidly and a chill arise.

The punkah does not, however, lower the temperature of a room or affect its humidity, but it increases the movement of air and thereby removes more heat from the body. Evaporation is usually accelerated by increased conduction, and thus the punkah helps to increase the amount of heat given off from the body. This increase of evaporation does not occur if the air is already saturated with moisture, hence a punkah cools more in a dry air than during the rains, or in the dry climate of Northern India in the summer than that of Lower Bengal.

When the temperature of the air of a room is much warmer than that of our bodies, the walls of the room having been heated by the sun and the hot air coming in from outside, there is no loss of body heat by radiation, all heat then lost is by evaporation, and the extent of this is regulated by the dryness of the air. Hence the heat with a temperature of say over 100° F. in a very damp air is felt much more than one of the same temperature with a very dry air.

In some stations with a dry atmosphere perflation and cooling of the air by *thermantidotes* may add to the comfort of the men in the hot weather, but as a rule they cannot be recommended, particularly in the case of the drier and hotter climate of Northern India before the rains set in (see p. 165).

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* *King's Regulations*, 1908, § 1008.

Water.—No uncovered water should be allowed inside barrack rooms, and the formation of pools and other collections of stagnant water outside barrack rooms should be prevented.

All filters and cisterns in barrack rooms should be in charge of men who have been specially instructed in the uses and care of them.

Wash-houses.—The wash-house should be kept clean and comfortable. There should be a sufficient number of basins in the ablution room. Men should always empty and clean the wash-hand basins after using them, even when, as should be the case, each man has his own basin. The wet towels after use should be hung up to dry, and not placed over or under the bed or under the pillow.

Gratings are to be supplied in front of the basin stands, over the central drain and in each private bath-room; these and the basin stands are classed as fixtures. Iron reservoirs, to contain about 120 gallons for a company wash-house, should be provided, and the water laid on from them with pipes and taps to the basins and bath-rooms. Eight bath-rooms are allowed per company on the plains. The private bath-rooms are to have doors and fastenings and pegs to hang clothes on. The wash-houses are 9 feet high if with a pent roof, and 12 feet if the roof is flat (A. R. I., Vol. XII).

There should be facilities at all seasons for men to bathe. In the hot weather these are usually provided in the shape of swimming baths in which clean water is constantly kept flowing in. In the winter, however, special arrangements should be made to provide a certain amount of hot water in wash-houses for men to bathe in. The question is a difficult one and chiefly connected with the provision of fuel. It is specially difficult where, as is usually the case in this country, the barracks are widely separated and no central bathing place is in existence. The present arrangements of company cook-houses in India do not lend themselves to the heating of large quantities of water for bathing purposes. Much can, however, be done and should be done, and for the present this must be left entirely in the hands of regimental administration, the point being that every man should have facilities for taking a warm bath at least once a week in the cold weather and a cold or a warm bath twice a week in the hot weather. This is essentially necessary for the minimum amount of personal cleanliness compatible with the prevention of skin diseases, vermin and sore feet.

The use of shower baths of hot water would be an excellent innovation as it saves about 80 per cent. on the amount of water required for immersion baths, and the space required is only two-thirds that for ordinary baths. With this it would be possible to supply the men with enough hot water for a daily bath.*

* Captain Lelean, R.A.M.C., *Military Hygiene.*

Night urinals.—In almost all barracks a movable pail or receptacle is used at night as a urinal; it is placed outside the barrack room and removed in the morning. This should invariably be a metal cylider provided with handles and a water-tight cover.

If located in verandahs the places where the urine receptacles stand are to be scrubbed every morning. The receptacles should be regularly tarred inside, and where abundance of water is available, filled with it during the day and emptied at night, or kept empty and exposed to the sun. When in use they should be partially filled with saw-dust, dried leaves, straw, or grass, and on the hills with pine needles, these being burnt and renewed daily. Night urinals require to be attentively looked after. A single typhoid fever " carrier " micturating on the ground instead of into the receptacle may be the origin of several cases of the disease.

Dust-bins.—There should be a dust-bin placed conveniently in the neighbourhood of each barrack. They should be movable galvanised zinc cylinders with handles and covers, located as remotely as possible from stored water and the kitchen. They should be emptied at least once a day. The " ground around ash-bins and other places for refuse should be cemented or hardened to prevent soakage of foul matter into the soil."

Section commanders should be held responsible for much of the sanitary cleanliness of barrack rooms and their surroundings.

Cook-houses.—The authorised floor is stone-paved, having a slope into a drain to facilitate washing the floor, this drain to discharge into a receptacle outside the building, and the *chuhla* platform is to be two feet six inches above the floor level with arched openings beneath. The floors of all kitchens should be constructed of some impermeable material to permit of their being scrubbed, and, if necessary, flushed. An oven should always be provided. Automatically closing doors with panels of wire-gauze should be provided for all doorways, and wire-gauze fixed in the windows in place of glass.

" Kitchens require to be kept sweet and clean, and cooking utensils, tables, chopping blocks, and all receptacles for food, should be cleaned at once after use."

A set of simple rules should be hung up in every cook-house. The following, abstracted from Major R. I. Blakham, R.A.M.C., *Military Sanitation* p. 76 *et seq.*, are an excellent example of what such rules should consist of.

Rules for Cook-houses.........Regiment.

1. Every person employed in the cook-house will *wash his hands on entering the kitchen.*

2. The master cook will be responsible that *special clothing is invariably worn by all persons.*

3. *Floors* will be *flushed out daily with hot water* and scrubbed with hot water and soap at least once weekly.

4. *Sinks and pipes will be flushed with strong soda solution made by adding two ounces of washing soda to a quart of boiling water at least once weekly.*

5. Jharans *will be given to each cook by the non-commissioned officer in charge daily. They will invariably be washed and stored under European supervision.*

6. All *refuse-bins* must be *kept covered and emptied daily.*

7. The non-commissioned officer in charge will see that *mutti* (earth) *is not used for cleaning cooking vessels. Bath-brick is provided for the purpose.*

8. The jemadar will be responsible that *any case of illness amongst the native cooks, or their families, is promptly reported.*

9. *Chopping blocks will be scraped daily.*

10. All milk will be boiled on receipt and kept in a covered receptacle till required.

11. *Sweepers are not to be allowed to enter the kitchen.*

12. The orderly officer will see that *all cooking utensils are properly cleaned and put away after the evening meal.*

All kitchen slops should be passed into a grease trap before it gets into the drains. Such a trap is easily made by filling a kerosine oil tin with dry grass soaked in kerosine oil, and perforating the bottom of the tin with a nail, the grass being burnt daily.

The slop water or sullage from the cook-houses and wash-houses of a unit of European infantry amounts to about 1,000 gallons a day, and being a highly putresible fluid this has to be got rid of somehow. Up to the present there is no really efficient method advocated for doing this that can be adopted in all stations successfully. The *bucket system* is now largely adopted for kitchens, the slops being discharged into covered iron receptacles containing from 5 to 8 gallons, which are kept just outside the cook-house. They frequently overflow and the surface around is constantly being soiled. This will continue until cement platforms for the buckets are provided. A nuisance is thus often created and flies swarm around. The contents of the receptacles

are emptied directly into the waste-water carts; the emptying of them permits of further pollution of the soil as the full vessels are not easy to empty without spilling. This, unless the slops were first passed through a grease trap or subjected to downward filtration in prepared soil, may lead to much offensiveness, and even with a trap and filter calls for daily attention. The carts convey the slop water to the night-soil trenches.

In the new pattern kitchen the sink will be in a separate scullery room and separated from the cook-room by a fly-proof door, and in it the cooks will keep their changes of clothing, and conveniences for washing the hands at all times will be available.

The floor should be brushed once a day, being previously sprinkled with moist used, tea leaves of which an abundance are always available.* This should never be done when cooking is going on. The sweeping should be done by the cooks.

All food should be carefully stored, and always protected from flies and dust which may directly infect it. Acute food poisoning may follow the use of food placed in dirty utensils, or in places fostering decomposition. Unfortunately cooking does not safeguard from this form of poisoning, for although it destroys the microbes that produce the ptomaines, the ptomaines themselves being more or less fixed chemical compounds, are unaffected by boiling.

Food should therefore never be kept in any place that is dirty, near dry refuse, latrines, urinals, or slop sinks of any kind in or near barrack rooms, huts, or tents.

The best way to store all fresh foods is to hang them up in a meat-safe or *dooly*, which is suspended in the open air from the roof of the verandah in the shade, so as to allow fresh air to reach it on all sides, the food material itself being kept in muslin bags to prevent the access of flies.

Each cook should have three suits of white clothes and three white caps. They should change their ordinary clothes for a white suit before beginning work; where the new pattern kitchens are erected this should be done in the scullery. They should wash their hands with soap and water before entering the cooking room or commencing work. There should always be basins, soap, and clean towels at hand for this purpose. The cook-house should never be used as a living room—no person should sleep in it. Flies should be excluded; this should be quite easy with automatically closing fly-proof doors and fixed fly-proof windows and sky lights.

* The tea leaves should be stored and any that can be spared used in the sweeping of the floors of barrack rooms.

Cooking utensils should be cleaned with boiling water, and when it is necessary scoured with powdered bath-brick from perforated tins, or ashes from the grate and cocoanut fibre or coir should be used. There should always be a sufficient number of clean *jharans* for cleaning and washing utensils; economy in their use always means dirty utensils. The slops of the cook-room should be received into a properly covered metal receptacle brought into communication with the kitchen sink by means of a lead pipe, the outer opening of which is covered with a fly-proof wire-gauze netting. On no account should kitchen slops be thrown on the ground outside the cook-house. The garbage and other dry refuse of the cook-house should be collected in a covered refuse receptacle which should be placed outside the cook-house.

No man should be employed in preparing or handling food unless he has been passed by a medical officer as fit for that duty. This would eliminate all "carriers" of such infectious diseases as typhoid fever and dysentery from cook-rooms.

The system of company cook-houses should be abolished and either two, or at the outside, four large cook-houses be made to answer the purpose. Two or more large dining rooms would be an excellent supplement to this.

Many experienced medical officers have recommended the introduction of some modification of the restaurant system for European troops in India, and it certainly has several points in its favour.

The cooking arrangements and food require to be strictly supervised by a European officer daily and systematically.

"Every man should be taught to cook in his mess-tin, and to make the best use of preserved rations, and also of uncooked flour which is occasionally issued to him."*

The fewer the natives allowed to prowl around and work in the lines of European barracks the better, and the number should certainly be reduced to a minimum at night.

The visits of peregrinating providers of all sorts of delicacies for the European soldier's consumption in barracks should be discouraged in every possible way. These hawkers through the unwholesome messes they sell as food are responsible for a certain amount of sickness in the service. The same remarks hold good with regards to the lines of Native regiments.

Soldiers, both European and Native, should never eat or drink anything in bazaars.

* Official (Home) *Manual of Military Sanitation*, 1907, p. 34.

As in camps the officer commanding companies, troops, and batteries of European troops, and the double company commanders in Native battalions, should be responsible that all orders connected with the sanitation of their company lines are carried out. In both European and Native regiments one man per company is sufficient for this.

Surface drainage of barracks.—There should be a complete system of surface drains in all cantonments. They should all be on one basis and form a complete whole. Those outside barrack limits will chiefly be concerned with carrying off rain-water, and whether they are *pukka* or *kutcha*, should be kept so as to work efficiently, and prevent stagnation of water in their course. The rain-water falling within the area covered by the regimental lines is usually carried off by natural water channels and roadside channels which are as a rule *kutcha*. These should be kept properly graded and free from accumulations of grass, weeds, and water plants.* These channels should convey away from 80 to 90 per cent. of the rainfall. The size of the cross-section of the drains required is estimated from the actual rainfall itself over the area to be drained. One inch of rain per hour per acre is equal to 3,360 cubic feet of rain; the calculation is made for the general maximum rainfall in an hour.

"For the removal of waste water from wash-houses, etc., wells, absorption pits or cesspools are dangerous and should not be used. The water should (*i*) either be collected in catchpits, from which the accumulations must be removed daily and sprinkled on the ground, or carried to a distance; or (*ii*) it should be led away in small masonry drains beyond the precincts of the barracks, with earthen drains in continuation, to convey it to trees or garden plots; if there are no trees conveniently near they should be planted at a sufficient distance from the barracks to avoid obstructing the ventilation; or gardens may be made and hedges planted in the *kutcha* channels." (A. R. I., Vol. XII, p. 31).

The best shape of drain is either semi-oval or U-shaped, which permits of easy drainage and flushing, and when necessary swept with a comparatively small fall. Neither V-shaped nor rectangular surface drains should ever be constructed.

Surface drains should never have their outfall into tanks or excavations in the vicinity of barracks. When this is done these excavations never dry up, and, apart from being a nuisance, are excellent breeding grounds for anophelines. There are several large cantonments in which *pukka* drains have been purposely constructed so as to empty their contents into such excavations. The initial planning of drainage schemes for sullage and storm water should be carefully carried out.

* See *Prevention of Malaria in Cantonments*, PART IV.

If not removed by drains, or taken to prepare garden soil by them, water from bath-houses and wash-houses gives rise to a disgusting puddle, and forms pools in which mosquitoes breed.

The surface drainage system for carrying off all cook-house slops and bath-house water is in use in many stations, the sullage ultimately flowing into some nullah or natural drainage channel on the confines of the barracks. Cook-house slops should be disposed of in this way without previously passing through a grease trap, as grease coats the drains with an offensive fatty slime that attracts flies.

All barrack surface drains should be swept and flushed every morning and evening, being careful to remove all clogging greasy material from them. Such clogging may be prevented by using dry grass or brushwood as a grease trap near the kitchens and wash-houses, this grass or brushwood being burnt and removed daily.

Where no drains exist the slop water from wash-houses conveyed in *kutcha* channels may be purified to some extent by constructing a trench 18 inches deep and 4 feet square, loosening the earth at the bottom of this, and filling it with 4 inches of rough broken stone, covering this with 6 inches of coarse sand, and this again by 6 inches of fine sand, and on the top a layer of stones or a perforated metal plate to keep the sand in place, and flies from gaining access. The sullage water in passing over and through this bed is filtered and in an absorbent soil the filtered effluent sinks in and is comparatively inoffensive. It is unsuitable for a clay soil. When the quantity of water to deal with is large two or more such filters will be necessary.

The *irrigation system* for wash-house refuse water acts best in a dry climate with a light porous soil such as sand, loam, black cotton soil and gravel. It is unsuitable for a clay soil. The garden, which is an integral part of this system, should be about 20 feet from the wash-house, and if possible the site should slope slightly. "The size of the garden required must be estimated by the depth of the porous soil and the amount of slops to be disposed of. Since a European soldier in India probably uses about 1½ gallons of water per diem for ordinary ablution purposes, and 4 or 5 gallons more for his bath, the total daily output of bath-house sullage water would be about 550—650 per company. But as every soldier does not indulge in a daily bath, the average number being three a week, the amount of slops to be dealt with per diem would probably not exceed 400 or 450 per company, and perhaps less in the cold weather."

The irrigation system of disposing of bath-house sullage has many points in its favour when properly carried out. It has been tried in several stations successfully. It cannot be adopted efficiently in connection with kitchen slops.

One would here emphasise the necessity of encouraging in all regiments, European and Native, the cultivation of vegetable gardens. This is specially necessary in Native regiments, as many of the men suffer in various ways during the summer from a want of an adequate supply of vegetables. There are very few stations in which such gardens cannot be established.

Latrines.—The latrines should be at least 100 yards from cook-houses. *Latrines are seldom free from some form of infective microbes.* About 3 per cent. of all men who have had typhoid fever are "carriers" of typhoid bacilli. Such men periodically pass large numbers of these bacilli in their urine and stools. With the dry-earth system plus the operations of flies, these bacilli may readily be conveyed to men's food or water, and it is supposed that this is one of the ways in which small groups of cases used to occur every now and then in barracks.

The Regulation in regard to latrines is:—"Floors are to be of earth, not paved. The planked seats are to be made movable to admit of cleaning. The screen wall of the sweeper's passage should have small arched openings at ground level to give through ventilation, care being taken that the pans are not exposed to view. The dry earth boxes attached to each seat are to be of stone or iron. The height of the privy pan is 8 inches (A. R. I., Vol. XII, p. 31)." The latrine accommodation provided is 5 per cent. of strength; where dry earth closets are used this should be 7 per cent. One would here condemn the use of earth floors for latrines. The floor should be raised, have a gentle slope, and be constructed of cement or some durable and impermeable material.

There should always be an adequate number of pails, and spare ones should be available if necessary. A double set is quite indispensable for cleanliness. The pails must be washed and disinfected after use. Clean ones that have been washed, disinfected with saponified cresol emulsion, and subsequently brushed with petroleum and exposed to the sun for several hours, should replace them.

It is very important that the pail or pan should fit closely under the seat. There should be no interval between the top of the pail and the seat itself. If this is not done, there is much risk of excreta finding its way on to the floor below the seat, which is not only disgusting, but also a dangerous source of infection.

The seats should be daily washed with soap and water and subsequently brushed over, above and below, with kerosine oil. Latrine seats should be dried after scrubbing so that men have no excuse for using unauthorised places, or for not sitting on the seats.

Latrines should be provided with an adequate supply of toilet paper Soldiers should use latrines in such a way as to keep them clean and inoffensive. All latrines must be carefully supervised.

All latrine floors should be sprinkled with a disinfectant daily; the one now chiefly in use is saponified cresol emulsion (1 to 160). This has so far been confined to the latrines of European troops, but one would recommend its use in those of Native troops also. The use of a garden syringe having a rose with fine perforations for this purpose would economise the disinfectant. Any loose soil on the floor should be sprinkled twice a week with kerosine oil, and thoroughly rammed. It should never be swept or brushed. All scraps of paper etc., on the floor should be removed by hand.

Dry earth closets.—In dry earth closets an adequate supply of finely powdered dry earth should be kept at the latrine with scoops to use it. The dry earth used should be above suspicion, and this is only obtainable by its being previously baked, and this is impracticable. "The average dry earth latrine in a tropical country becomes in too many cases nothing but a centre of infection, the air of which is laden with excrement, tainted dust, and infected with flies, the bearers of equally disease-giving matter." Most experienced military medical officers have lost faith in the old dry earth system, and I have personally no hesitation in condemning its use for the latrines of all troops in India. The principle is good; and if carried out in its integrity, the objections to the system would be few. but it requires more attention to detail than has hitherto been given to it, or than it is likely to receive. The great difficulty is that of causing men to cover the excreta with dry earth. This is a *sine qua non*. In the absence of this, flies, one of the great disseminators of disease, are rampant. The carelessness of sweepers in the transfer of excreta to the night-soil carts, and the cleaning of the pans is another grave objection. No pail system in India can be successful in the absence of European supervision as to details.

"**Wet system.**"—What is now known as the "wet system" has largely replaced the dry earth system in the latrines of European troops. In it the pail is charged with a 1 to 160 solution of saponified cresol which acts as a deodorant, prevents the multiplication of bacteria, and prevents flies laying their eggs in the excreta.

All latrines should have a well-lighted lamp in them. The same remark applies to urinals in barrack-room verandahs.

The latrines allotted to company, squadron or battery barracks, should only be used by the men of those barracks, and not promiscuously by men of other barracks. This helps to localise infection

should it occur through latrines. It is very desirable that the latrines be visited daily by the orderly officer of the day. This to some extent keeps all concerned on the *qui vive* and ensures that attention which their cleanliness demands.

All removal of excreta should be carried out during the day time when it can be properly supervised and its defects observed.

Laundries.—All battalions should have their own laundries. These are provided in many stations now and are a vast improvement on the old system in which the clothes of all ranks were taken to the bazaar and frequently infected there. A large number of Native regiments are still, however, without laundries, and without any definite system by means of which infection through clothes sent to be washed is eliminated.

The cleanliness of the *dhobie* ghats in all cantonments is a matter that should be strictly attended to by both regimental and cantonment authorities. One would recommend the establishment of a laundry in every cantonment where this is possible, which should be closely watched by the sanitary officer of the station. Where this is not possible it is always easy to allot a particular well for the regimental *dhobies*, from which the water may be drawn by a hand-pump into an elongated trough, the *dhobies* standing on a raised platform and using an ordinary washing board or even a stone to beat the clothes on as they do at *ghats*. Arrangements should also be at hand to boil such articles of clothing as need boiling. The custom of allowing European and Native soldiers' clothes to be taken to the bazaar and mixed with a mass of possibly infected linen cannot be condemned too emphatically

If *dhobies* are allowed to wash according to their own methods they will use some filthy stream, pool, or public bathing place, which is already probably infected with the germs of one or more diseases.

Aerated water factory.—It is necessary that sterile water only is used, and this is best secured by boiling the water and passing it through a Berkefeld or Pasteur-Chamberlain filter. If such a filter is used it should be in charge of some non-commissioned officer or soldier who knows all about its use, how to take care of it and clean it. All the candles should be boiled every fourth day. The bottles should be washed in boiled water that has been allowed to cool and then pinked with permanganate of potassium—a dessertspoonful of the crystals to 14 or 16 gallons of water—or put into a half per cent. solution of formalin for several hours, and finally, before filling, washed out with sterilised water.

Sterilised water should be used in making the various syrups, and they should be stored so as to be inaccessible to flies The factory should be provided with fly-proof windows and doors, the former as wire-gauze panels, the latter self-closing, so as to be inaccessible to flies.

The mineral water factory requires to be carefully watched both as to the filtered water used, and the way bottles are cleaned, and this applies to both European and Native battalions.

Barrack inspection.—In the routine inspection of European soldiers' barracks the following are the special buildings to which the medical officer should direct attention and the points to be noted :—

Barrack rooms.—Observe the means of ventilation and general cleanliness, whether the doors and windows are kept open ; note whether there is any overcrowding. The number of men to occupy each room should be notified on the door. See if there is any accumulated dust on the floor, furniture, etc. Note the condition of the dining tables, presence of exposed stored food, etc.

Wash-houses.—Observe the general state as to cleanliness, the number of baths, wash-hand basins, and whether these latter are clean. Dirty basins may give rise to various diseases.

Company kitchens.—See whether the cooking arrangements are satisfactory and the ranges in good condition. Wash-hand basins with towels, soap and abundance of water should at all times be available for the cooks. The week's menu of the company should be scanned to observe if it is sufficient in quantity and not monotonous. Note any obvious uncleanliness about the cook-room, the state of the *jharans* in use, and ascertain whether they are regularly scalded every day. See if there are any sweepers in or near the cook-room—this class of persons should never enter cook-rooms. See whether the native cooks and their assistants are clean in person and clothes. All natives employed in cooking should discard their outer garments on beginning work each day and be provided with a white smock and cap. Note whether the pipe or drainage outlet leading from the kitchen to the slop container has a fly-proof wire-gauze covering.

Latrines and urinals.—Observe their state as to cleanliness of floor, seat and ground beneath the seat ; whether the urinals are clean and not foul smelling, whether there is any caking observed in the utensils, and whether they are properly tarred. Note the presence or absence of flies. The latrines of married quarters require special attention on account of the way children soil them.

Regimental workshops.—Observe the state of cleanliness and ventilation.

Canteen.—Note its state of cleanliness, ventilation, condition of latrine and urinal connected with it.

Guard rooms. Observe the condition as to cleanliness, the prisoners' room and the urinal attached to it; the nature of the covering of the men on duty and of the prisoners—extra blankets may be necessary ; ventilation and whether the ventilators are open and in working order ; the ablution arrangements and whether they are sufficient ;

the condition of the latrine. The food of men on guard should be as well served as in the barrack room, and it should always arrive in a hot state. That of the men on sentry should be kept warm until they are relieved. Hot water trays are a useful accessory in such cases.

Married quarters.—In inspecting these inquire particularly into the health of the children and see the condition of any that are confined to their rooms from sickness. Inspect the latrine.

Schools.—Note the average number of children attending, the means of ventilation, whether the air is fresh or not, the children clean and healthy-looking or otherwise. Note the water-supply, and the state of the latrines and urinals. Find out if any children are absent and if so the cause of such absence. Note the method of lighting the school room.

Coffee-shop.—When the coffee-shop is in the hands of a contractor it should be carefully scrutinised. All articles sold as food should be seen. When it is run as a purely regimental institution they are as a rule sound in every sense. Note the state of the latrine and urinal, if those conveniences are attached—they are in these places often much neglected especially after dark, the sweeper often being absent and the whole place foul and neglected. The latrines and urinals connected with all the institutes in regimental lines require special attention, and as these instiutes are visited by men who remain there until last post, sweepers should remain on duty doing the same work they do during the day time until that hour.

The number of the institutes to be inspected at different stations varies considerably—thus at Lucknow there are 22 different institutes—including dairies, markets, mineral water and ice factories, etc., so that the task of the inspecting medical officer is sometimes a fairly comprehensive one.

Inspection of men.—This is best carried out in the barrack room. The men should have their shirts open in front aud part of their chest exposed, and the sleeves rolled up. The feet should be bare. Note specially the state of the gums, skin, and feet (whether dirty or not); whether the skin is hot to the feel; note if the shirts are clean or not.

During these inspections it is well to have a European commissioned officer present, especially the quarter master. Many defects found may be remedied by a few words with this officer or the adjutant. It may happen that the matter is too serious for mere verbal reference, in which case the medical officer puts his views in writing to the officer commanding. All medical officers inspecting barracks should keep up the diaries of their inspections regularly, noting the special points observed calling for remedy, the recommendations made, the action taken and the results. During their inspections all points calling for remark and action should be entered in a note-book.

The inspection will also include a visit to the dairy, bakery, laundry, Army Temperance Association rooms, regimental bazar, followers' lines, and kitchen of officers' mess, gymnasium and drill shed. This last named should be thoroughly well ventilated, preferably open all round, and close to the parade ground

Each regiment should form a mosquito brigade for its own lines, working under the sergeant of the sanitary police, and guided by the officer in medical charge or by the cantonment sanitary officer.

(*b*)—*Native Troops.*

Accommodation for Native troops.—Accommodation is provided for Native troops by the Military Works Service or Public Works Department, wholly at State expense within fortified posts and works of defence, and at places where details are temporarily detached and often relieved. In other cases barracks and their subsidiary buildings are only built under the special sanction of the Government of India. In all cases the following buildings are constructed at State expense:—Quarter guard and cells, armouries, magazine, amourer's shop, quartermaster's stores, hospital and its subsidiary buildings, and wells or water-supply.

The authorised accommodation per man for Native troops in the plains is 60 square feet of floor area, and 810 cubic feet of air space, and in the hills 50 square feet of floor area and 600 cubic feet of air space. The barracks are in practically all cases built regimentally from special grants allotted by Government. Hence it arises that there is no fixed pattern of barracks for Native troops, and many varieties are in existence.

A great deal of what has been stated in regard to the site, construction and sanitation of European troops' barracks apply also to the barracks or huts of Native regiments. It is therefore only necessary to mention a few additional points that strike one as calling for special attention.

In no case should the floor of the barrack consist of the bare surface soil, and the floor should never be below the general surface. One has seen native troops barracks in which these rules have been departed from.

The huts should be elevated from the surface by means of a plinth of 1 or 2 feet, to keep them dry and facilitate drainage.

Leeping the floors and walls of Native troops' barrack rooms with a mixture of water, clay and cow-dung, or clay and water should be absolutely prohibited. It is a most insanitary and unwholesome custom. This, one is convinced, is responsible for a certain amount of disease and inefficiency.

There should be an adequate number of windows of sufficient size. The ventilation arrangements should, as far as practicable, correspond with those of European troops' barracks.

In damp soil, a damp-proof course should be laid on the lower part of the walls, this consisting of some form of hydraulic cement which is allowed to set properly, or of impermeable stone set in cement or tarred brick, etc.

The floor of the hut should, whenever practicable, be covered with concrete or cement. If this cannot be done then it may be formed of stone or wood.

The *walls* are usually made of any available material; sun-dried brick, burnt brick, bamboo covered with a layer of mud (wattle and daub), bamboo framework with wood posts, wood planks, corrugated iron, etc.

The *roofs* are made of thatch, grass or straw, tiles, or cocoanut matting, fibre of plantain leaf, or corrugated iron; grass or straw (*chapper*) roofs are the coolest, but are highly inflammable and soon rot; they form a home for birds, squirrels, snakes, and are a favourite haunt for mosquitoes. Thatch roofs are for these reasons here condemned.

A very prevalent custom, and one that should be strictly forbidden, is that of beginning the building of huts by excavating the earth, which is mixed with water, and using it for making the walls around this pit, which is finally filled up with rubbish or made soil, or any available refuse in the vicinity. Or pits are dug in the neighbourhood of the future huts and the material used for making the huts. These borrow-pits are allowed to remain. In the process of excavation of the subsoil, water is often tapped, and is then used by the men, sometimes for drinking; this pit often forms the starting point of a surface well, or if not used for drinking, this water may be used for washing clothes or ablutions after defæcation, or in it cows and buffaloes wallow, or it becomes a reservoir for all kinds of refuse. The digging of these borrow-pits should never be permitted. All material used for building should be brought from allotted places outside the site selected for the huts.

Inspection of Native troops' lines.—The medical officer of Native units should make a complete sanitary inspection of the lines at least once a week, and oftener whenever special circumstances require it. This inspection should include every barrack room, the guard room, cells, school room, etc., the points to notice being the same as those of British soldiers' lines allowing for the differences in the conditions of life and surroundings.

The inspection should include the immediate surroundings of the barracks, especially *kutcha* drains, excavations in the soil that may be used as latrines, and swamps, pools, etc., that might be breeding places of anopheline mosquitoes.

Once a week, where the battalions have their families in the lines, the medical officer should see all the women (except in regiments in which they are *parda nashin*) and children. He will often in this way

come across cases of infectious disease such as conjunctivitis, itch, etc., that remain untreated and a source of infection to healthy people in the lines.

Latrines.—The medical officer should see that they are kept clean, and free from offensiveness; and that the pails, receptacles, and night-soil carts are in a state of repair and properly tarred; that deficiencies are at once made good. It sometimes happens that the sweepers allow the pails to remain full or even overflowing for most part of the day, instead of periodically removing and replacing them with clean pans. The place where this cleaning is carried out will often be found to be very foul. The receptacles will sometimes be found without covers, or the covers damaged, or carelessly adjusted.

The place where the men carry out their ablutions after using the latrines are sometimes in a very unclean state. There should always be definite arrangements for this, and men found using *nullahs* or other form of cover outside the latrine for the purpose should be punished.

The married quarters and their surroundings require constant watching, especially as regards ventilation, lighting, cleanliness, deposir of refuse in their vicinity, and use of the general surface of the ground as a latrine by the children. The latrines and the ablution arrangements connected with them call for special attention; the water used in the latter often forms a stinking puddle outside the latrine. It is necessary for us to insist on the married people living healthy lives and their children being brought up in the ideas of hygienic cleanliness, personal and domestic, for a fairly large proportion of line boys become our future soldiers.

We should endeavour to inculcate the principles of personal and domestic hygiene into our Native troops so that they may, when pensioned, carry these principles into practice in their own villages, build better houses for themselves with better ventilation and lighting, and better sanitary arrangements generally, and so by their example influence those around them.

When the *water-supply* is from wells it should be analysed chemically twice every year, before and after the rains. When there is a bacteriological laboratory in the station the water should also be subjected to a routine bacteriological examination. Men should be strictly prohibited from using unauthorised water for drinking purposes, or for cleaning their eating and cooking utensils.

The *milk* sold in the bazaar should be frequently examined. Hawkers of milk and food-stuffs should be forbidden from entering the lines. If goat's milk is used it should be invariably boiled before use. Where goats are kept in the lines or goat's milk used, a regimental order should be periodically published (once or twice a year) warning men that unboiled goat's milk may give rise to a serious form of fever

Nothing that is used as food and drink by the men in barracks should be sold that has not been passed as fit for consumption by some responsible person.

The hospital latrine should be inspected daily. Some arrangement should be made to systematically incinerate the excreta of all cases of infectious disease, including the sputa of cases of tuberculosis of the lungs and pneumonia. There is seldom any difficulty in doing this.

The *regimental bazaar* and surroundings have to be kept constantly watched in the same way as the married quarters. The food-supplies sold should receive special attention, and the nature and quantity of the vegetables and fruit exposed for sale noted.

It is specially necessary in carrying out sanitary measures to do nothing that will interfere with the religious prejudices and customs of our Native troops which are always to be respected, nor to in any way violate the sanctity of any place held sacred by them.

In his weekly inspections the medical officer should be accompanied by the sanitary havildar. Any minor defects in the sanitation of the lines easily remedied should be brought to the notice of the quartermaster, in larger matters to that of the officer commanding the regiment. The result of the week's inspection should be noted in the medical officer's official diary.

Precautions regarding Infectious Diseases.—Medical officers will in October each year, and whenever small-pox prevails in the station or its environs, take steps to vaccinate or revaccinate all persons in their respective charges, who do not show satisfactory marks or records of successful vaccination or re-vaccination. Recruits, if not vaccinated at the recruiting depôts, will be vaccinated on joining. All children in the lines will be re-vaccinated at the age of ten years. These orders do not of course apply to persons who bear signs of previous small-pox. Supplies of fresh lymph should be applied for from the vaccine depôts of the Province.

Cases of tuberculosis and pneumonia may be better treated in verandahs than inside wards. Cases of other infectious diseases should be treated either in the infectious diseases ward, isolation ward, or in old condemned tents.

All disinfecting operations, whether in barracks, hospitals, or camps, should be supervised by the medical officer of the unit. For barrack rooms and hospital wards sulphur dioxide gas should be generated by burning sulphur (3 pounds to each 1,000 cubic feet of air space). Cresol is also a useful insecticide and may be used as such.

In all large stations there is a sanitary officer for the week. Nevertheless medical officers of units are still personally responsible for the sanitation of the lines of the regiments to which they are attached.

Neither European nor Native soldiers should be "detained" for more than 24 hours. At the end of that time they should be either admitted into hospital, or sent back to duty. One has during the last two years visited at least ten regimental hospitals in which men are detained for several days, or made to attend daily for medicine, or "granted line leave." This practice is not sound as it is impossible in such a regiment to form an opinion as to its state of health as compared with other units in which the regulations on this point are rigidly adhered to; the individual may after being repeatedly detained in this way show a clean medical history sheet, and the custom interferes with a true estimate being formed as to the amount of accommodation required in the hospital and the supplies necessary for the sick.

In all cases of infectious and contagious disease the medical officer should make sure that all nursing orderlies and hospital attendants who are detailed for duties in connection with these cases are quite familiar with the nature of the risks they run, and that they carry out all instructions regarding disinfection of their hands, clothes, etc., that may be issued with a view to reducing these risks. Except in the case of permanent ward orderlies, the sick attendants on infectious disease cases are to be entirely voluntary.

Cases of venereal disease are only to be admitted into the general wards of the hospital if special reasons exist, such as the necessity of careful nursing, etc.

The examination of all fresh cases of both European and Native soldiers whose names are borne on the morning sick report should invariably be thorough. This is the best way to avoid errors in diagnosis and missing the early signs of serious disease, or those of latent disease now manifest for the first time. It is also the most reliable way of eliminating schemers. Whenever in doubt about a case it is always better to either admit, or detain the man for 24 hours for further observation. In the morning the early signs and symptoms of infectious disease are less marked than in the evening. A slight headache in the morning with a little coating of the tongue may be the early signs of many diseases that are to become serious.*

SANITATION OF CANTONMENTS.

There are various matters connected with the sanitation of cantonments which are to some extent connected with the sanitation of regimental lines. Some of these are administered regimentally in the case of European troops, some by the Supply and Transport Department, but usually they are worked by the cantonment authority under the *Cantonment Code*. We will now deal with the more important of these.

* In the foregoing section I have been greatly indebted to the very useful little *Handbook for Officers of the Indian Medical Service in Military Employ*, by Capt. H. Boulton, I.M.S.

A.—Dairies.

Cow-sheds and dairies should be properly lighted, ventilated and drained, and they should be supplied with abundance of water.

All cow-sheds should be kept on the outskirts of cantonments, and when in the interior they should be built on selected sites. Cow-sheds should be provided with a roof, and be either completely open all round, or have only a low wall.

These sheds should have a smooth impermeable sloping floor with drains so arranged that the whole floor may be thoroughly washed daily, and the water flow into a metal receptacle which is protected from rain and flood water. This receptacle should be emptied every day.

Arrangements should exist to guard milk against exposure to contamination or infection. We have already seen how easily and from how many sources milk may become infected by disease-germs (p. 187).

The dairy in which the milk and milk utensils are kept should be quite separate from the cow-shed, and quite disconnected from the dwelling houses of the *gowallahs* and those who look after the cows. The milk-shed should be provided with arrangements to scald all utensils and bottles used to contain the milk.

When the water-supply is from wells, the well should be at a distance from the cow-shed and from the place allotted for the accumulation of manure. The well should, if possible, be a covered one, and provided with a pump.

All parts of the cow-sheds, milk-sheds, storage rooms, and all parts used in the preparation of sterilised milk, cream, butter and cheese. should be kept thoroughly clean.

The cows should where possible be cleaned, fed, and milked under European supervision. The udder of the cows or buffaloes and the hands of the milker should be washed before drawing the milk. All utensils containing milk should be scalded daily, for which purpose there should be abundance of boiling water provided. When dairies are kept up by Native battalions, the same precautions, *mutatis mutandis*, should be observed.

The dairies of all large stations should, as far as practicable, be grouped into one. The accumulations of cow dung in several parts of cantonments is a certain attraction to flies, and it is undesirable to maintain a multiplicity of foci where flies may breed.

The poorer class of *gowallahs* cannot in all probability erect healthy cowsheds built on sanitary principles for his cattle. For such cases the cantonment authority should consider the advisability of erecting

cowsheds, and having these properly supervised, charging the *gowallahs* a small rent for the use of them. One has carried out this method of removing a terrible nuisance in a large municipality with excellent results.

In the case of cow-sheds on the outskirts of cantonments the cow-dung should be stored in a small open shed having a roof, the floor being raised to prevent access of flood-water. In this way it may be allowed to dry, or it may be made into fuel cakes (*bratties*) and plastered on the walls to dry. It is important to prevent its admixture with rain-water which brings about decomposition and a disgusting nuisance. The collection and storage of cow-dung in cow-sheds in the interior of cantonments should, as far as practicable, be prohibited, and if this cannot be done, the precautions recommended above should be insisted upon.

Gowallahs should be forbidden under penalty from feeding milch cows or buffaloes with any form of stable litter or refuse. All *gowallahs* and purveyors of milk should be registered.

The insanitary condition of *gowallahs*' premises formed one of the worst nuisance with which one had to contend when health officer of a large municipality. Cow-sheds and dairies invariably call for the most constant supervision and control.

All milk in this country is subject to contamination even when drawn in the compound under strict supervision. It should always be boiled before use, and when used by our European soldiers this should be done in the kitchens under responsible supervision, even if it has been done previously in the bazaar or elsewhere. It should be kept in a clean locked can. The can used should first be scalded with boiling water. After boiling the milk it must be carefully covered to keep out flies and dust.

B.—Bakeries.

Bakeries require constant watching. They should be under responsible European supervision. The rules regarding cook-houses to a large extent apply to them, and a set of these rules, with such modifications as are necessary, should be hung up in the bakery. All stages in the process of bread-making should be carried out in a clean manner. There should be means of washing the hands and arms of the bakers employed, and they should always have a clean suit of white material to wear before commencing their work. The bakery should not be used as a residential building on any account. No person should sleep in it. The flour should be kept in metal receptacles or wooden bins. The table used for pastry-making should be provided with a slate, plate-glass, or marble slab, or smooth hard wood.

The floor should be of stone slabs or smooth cement so as to be washable, and the doors should be provided with automatically closing wire-gauze panels, and the windows with fixed panels of the same kind.

C.—Slaughter-houses.

The nuisance connected with a slaughter-house may arise from accumulation of filth on or about the premises, or be due to its removal from the premises in an offensive condition, or a generally filthy condition of the interior of the building, the premises, and the utensils, an improper method of disposing of offensive refuse, liquids or solids, or carelessness in the disposal of offensive material.

Decomposition of animal matter and garbage is the chief cause of the injurious influence of slaughtering animals near inhabited places. Except in properly constructed shambles, in the process of killing, large volumes of blood flow over the ground and soak into it. Following this we have the cleaning of the entrails, their contents being scattered about the slaughtering place; decay soon begins and continues until the next day's slaughtering commences. If there are drains the blood flows into them, but its offensiveness does not cease in them; for instead of being limited to the area of the slaughter-house, it becomes diffused, and putrefaction of this animal matter goes on along the entire line of the drain. Such processes as these are bound to effect the health of those dwelling in the neighbourhood.

Any one who wishes to verify these statements, and to ascertain the nature of the nuisance, has only to visit a large and neglected slaughter-house in or near an Indian town. In a large slaughter-house which we inspected several hundred sheep and goats were slaughtered daily. The offal, dung, etc., of the animals remained on the ground sometimes for days, and the soil was saturated with the decomposing blood that had soaked in it. The result was a condition unspeakably revolting.

In all cantonments there should be a special place allotted for the slaughtering of animals. In camps this may be conveniently carried out under trees at a distance from the camp, but in large cantonments it is necessary to erect proper slaughter yards in the outskirts.

In making such slaughter-houses, one would urge the necessity of attention to the following rules:—The sites for slaughter-houses should be approved of by the cantonment committee. They should be at least 100 yards from all dwelling houses. They should be thoroughly ventilated by being in direct communication with the external air on all sides. In most cases, a single shed surrounded by low walls and a roof, and a properly laid impermeable floor with drains are all that is required. A roof is always to be constructed as it keeps out sun and

rain and keeps off kites and crows. The beams of the shed should be provided with hooks on which to suspend the slaughtered animals. A room for hanging carcases for a while after slaughtering is desirable. The floor of the slaughter-house should not be below the level of the surrounding ground. A cistern for abundance of water should be supplied to keep the place clean, or where there is a public water-supply a sufficient number of taps should exist to effect this purpose. The floor should be covered with smooth cement or paved and have a slope inclining to a channel which should be laid all round, or the floor may slope from both sides towards a central drain. The channel or drain should run to a movable receptacle. Sometimes cement lined cisterns are used, but these are highly objectionable.

The surface of the walls in the interior of the slaughter-house should be covered with hard smooth cement to a height of three feet at least. They should have a clear area all round permitting of thorough ventilation of the slaughter-house ; and a plentiful supply of water for animals awaiting slaughter should be provided. The slaughter-house yard should also be properly drained. No latrine, urinal, or cesspool should be constructed within the slaughter-house enclosure A latrine should be erected at a distance from this enclosure, and it should be kept thoroughly clean, and used only by the persons engaged at the slaughter-house.

Slaughter-houses, when in use, should be cleaned daily. The refuse from slaughter-houses should be removed in covered receptacles.

Slaughter-houses should never be allowed in buildings not specially provided for this purpose. All slaughter-houses should be filled with proper appliances and should never be in the denser parts of the cantonment. Attempts to adopt old dwelling houses to the requirements of slaughter-houses are always failures. The slaughter of animals in other places should be strictly forbidden. Whenever possible the slaughter-house should be erected by the cantonment authority and not by private individuals, rent being charged to each person for the use of the building. This is preferable to renting the entire building to one man, who sublets it.

The chief points connected with slaughter-houses are—(1) Initial construction to be in accordance with the requirements of slaughter-houses ; (2) regular supervision ; and (3) insisting on the rigid observance of a carefully drawn up set of bye-laws.

D.—CEMETERIES, ETC.

The manner of disposal of the dead of our large cantonments is a matter of much importance. It is now generally held that *cremation* or burning of the dead is the most speedy, cleanly, economical and wholesome metho of paying this final tribute. With certain sect

of Hindoos this is the orthodox method of disposing of the bodies of the dead; but with Europeans, other classes of Hindoos and Mahomedans, prejudice and custom cause the disposal by burial for the present to be the most popular method. The existence of graveyards is still inevitable. Regarding these we will lay down a few general rules.

Site and soil of cemeteries.—The soil of cemeteries should be dry so that ground water shall never rise high enough to wet the corpse; they should be as far from inhabited dwellings as is convenient and practicable—100 yards is the nearest permissible limit to the cantonment for cemeteries.

There should be good drainage to permit of a free flow of surface water and the water should not run into any well or water-course from which drinking water is taken.

If there is a choice of sites we should select a dry porous soil such as sand and gravel which allows free penetration of the air and the moisture necessary to permit the micro-organisms associated with the decomposition of animal matter to do their work. Where only low-lying flat ground is available for cemeteries, the level of the cemetery plot should be raised several feet to permit of drainage.

The graveyard should be surrounded by good walls, the area arranged in plots, and pathways made to permit of easy approach to the plots.

Burial should be in graves of not less than 6 feet deep with a lateral interval of 2 feet between each grave. Bodies should be interred in regular lines. More than one body should never be buried in the same grave.

Rapidly growing plants and trees such as *casuarina* and *nim* should be grown in lines between every three or four plots and pathways.

Wells or tanks in or near burial grounds should be closed, fenced in, and notices forbidding their use posted on them.

There should be no possibility of the drainage of the cemetery gaining access to any present or prospective source of water-supply, whether this be from wells, rivers, streams, tanks or other sources.

The bodies of persons dead of infectious or communicable diseases should be cremated or buried as early as possible, and not kept in the hospitals or anywhere in cantonments for unreasonably long periods while funeral rites are being carried out. Bodies likely to disseminate infectious disease *en route* to the cemetery or crematory should, before removal, be wrapped in a sheet saturated with some powerful disinfectant, such as 1 to 1,000 solution of perchloride of mercury, or 1 to 20 carbolic acid solution, etc.

In overcrowded and disused cemeteries further burial should be prohibited and the ground properly fenced in; any visible remains of human bodies should be re-interred, all hollows filled up, the whole surface ploughed and levelled, and all undergrowth, scrub and jungle should be cleared away. The whole area should be kept under cultivation.

Overcrowded and badly regulated cemeteries have repeatedly been proved to be injurious to the health of the population dwelling around them. There is no evidence to show that a properly regulated cemetery at a distance of anything over 300 feet from human habitations is injurious to health.

The dangers associated with cemeteries are—contamination of air and water, and the possible effects arising from the germs of specific disease, some of which can undoubtedly live (and in a few cases multiply) for some time in earth. Some germs appear to multiply in the deeper layers of the earth and not in the superficial.

All cemeteries, including those that are disused and overcrowded should be under the immediate control of cantonment authorities and their administration should be exclusively carried out by those authorities.

No burning *ghat* should be within 500 yards of the nearest barrack to it. The area used for the purpose of cremating bodies should be marked out. When on the banks of a river or stream it should be below the sites chosen for water-supply, bathing and washing clothes. The cremation should be thoroughly completed in every corpse. Burning *ghats* require close supervision.

The throwing of dead bodes into rivers and streams should be strictly forbidden within cantonment limits; this is not only repulsive, but may in the case of bodies containing the infective material of disease disseminate the latter. This is believed to be one of the ways in which cholera in an epidemic form arises in India by river water becoming specifically polluted.

Animal sacrifice.—Where the sacrifice of animals is customary, earth or ashes should be spread on the ground in a thick layer where the sacrificial ceremony is to take place, so that the blood is absorbed; this earth being removed as soon as the ceremony is terminated.

E.—Artificial Lighting in Cantonments.

The artificial lighting of cantonment and barrack roads and streets has so many obvious advantages that it is unnecessary to dilate upon them here. Besides being a general convenience and facilitating traffic, it prevents the commission of nuisances.

The light from kerosine oil lamps is neither powerful nor of the best quality; the expense and labour connected with them are heavy, and they need constant care and attention. They take up much time in looking after them, and the wear and tear is considerable. Nothing can be said in their favour when comparing them with coal gas or electric lighting On the whole, however, mineral oil lamps used with the best oils give a fair light.

F.—Destruction of Brushwood and Jungle.

All brushwood, scrub, all kinds of jungle, rank weeds, and prickly pear (*cactus*) in cantonments should be periodically cleared and removed or burnt. They afford a repository for all manner of refuse which ferments and putrefies, are used as cover for persons committing nuisances, and for snakes and other reptiles and rats to secrete in, interfere with ventilation, attract water to the subsoil, are constantly decaying, and in every way objectionable.

In cantonments, the vegetation should be cut down and removed at once, or, after being allowed to dry burnt on the ground which should be dug over so as to turn up and destroy the roots. Annuals should be destroyed before the formation of the seed.

The clearing of jungle should be carried out methodically. Jungle should be eradicated at the proper season. To cut down wild arum (*kochu*) and *bherinda* at the beginning of or during the rains, is worse than useless, for the jungle springs up again and the cut plants rot on the ground. The proper time for jungle cutting is either at the beginning of the hot weather, or after the complete cessation of the rains.

The lower branches of trees shonld be pruned off, this training being carried to a height of 10 or 12 feet, to allow of free ventilation of air and the passage of vehicles beneath them without inconvenience.

All forms of wet cultivation should be prevented in the immediate neighbourhood of cantonments. Damp, vacant, and bare sites of ground may be planted with such rapidly growing trees as *casuarina* and *nim*, and the same should be done between cantonments limits and any adjacent undrainable extensive marshy ground.

Irrigated lands in the neighbourhood of cantonments are unhealthy because of their fostering the breeding of mosquitoes. When soils are thoroughly well cultivated they are mostly healthy, notwithstanding the periodical application of manure to the land.

G.—Brick Factories.

The manufacture of bricks either in kilns or clamps should not be allowed within 1,000 yards of any cantonment. In no case should permission to open a brick factory be given until the site has been approved by the sanitary medical officer of the station.

H.—Dry Refuse and its Disposal in Cantonments.

Meaning of dry refuse.—Dry refuse consists chiefly of garbage, the peelings and unused parts of food, vegetables and fruits, ashes, sweepings, paper, rags, and the droppings of horses, cows, and other animals, and various used-up articles of barrack-room life. This refuse contains a considerable amount of organic matter which rapidly decomposes, and in doing so gives off foul gases. This takes place much more rapidly in the presence of water. It is very necessary, therefore, that refuse be kept *dry* ; no refuse water or slops are to be mixed with it. Further, it is necessary to remove this material periodically, but we require some system to work on in order that we may efficiently remove the dry refuse from all parts of a cantonment or camp.

The removal of dry refuse from cantonments requires that (1) there should be dust-bins disposed over the barracks, cook-houses, officers' and other bungalows ; (2) a sufficient number of rubbish carts to remove at least once (preferably twice a day) the dry refuse collected in the dust-bins, with an establishment of drivers and sweepers for the carts and collection ; and a (3) system of final disposal inside or in proximity to cantonments either by incineration or otherwise. The number and size of carts and strength of the establishment required depends on the actual amount of refuse to be removed and the distance it has to be taken for final disposal. In large cantonments it is advisable to have several places to which the refuse may be taken to.

The dust-bin is a movable ashpit, usually cylindrical in shape and made of galvanised sheet or galvanised corrugated iron with tight-fitting lid. This pattern is easy to clean and facilitates direct transference of the refuse to the refuse cart. They are infinitely superior to the old brick ashpits which should be condemned and demolished wherever they exist.

The best way of finally disposing of the dry refuse of cantonments is by incineration, and any one of the incinerators described later on may be used for the purpose. As a matter of fact a certain amount of this refuse is used as fuel for night-soil incineration in a large number of cantonments at the present time.

Dry refuse for filling tanks, borrow-pits, etc.—There are many small and large tanks and collections of surface water generally forming breeding places of anophelines in and around cantonments, that could, without risk to health, be filled up with dry refuse. This should not be done, however, when such excavations are within 400 yards of bungalows and barracks. Stable refuse will form breeding places for flies unless special care be taken to render it uninhabitable to maggots. The best way to do this is to keep the refuse dry. In all cases the final levelling should be carried out with a layer of earth several inches deep. When filling up large excavations with dry refuse is decided upon, the work should be carried out systematically, beginning during the cold weather, and where possible completing the work before the onset of the ensuing rainy season. If the capacity of the excava-

tion is too large to complete the filling and levelling before the rains, it should be divided up into sections by one or more *kutcha bands* or mud walls, and each section taken in turn, the object being to prevent decomposition and fermentation through admixture with water. The earth for these *bands* may, if there is no rising ground in the neighbourhood, be taken from the margin of the excavation.

The shallower parts of tanks and excavations that retain water should always be taken in hand first, and the deeper parts taken up finally, each part being finished before the next is started and before the rains begin. A large number of tanks could in this way be filled up and levelled at a comparatively small cost, and in places where there is little or no earth and draining is impossible, this is the only way available without inordinate cost.

The length of time it takes to fill tanks and borrow-pits generally is readily calculated by ascertaining their capacity together with that of the amount of dry refuse available daily.

When the work is begun in the spring of the year, the shallower parts of the excavations, which will in many places have dried up, should be taken in hand first and shut off from the deeper parts by *bands*.

The deeper parts, also divided into sections if necessary, should be finished before the beginning of the ensuing rains. In the case of these deeper parts of tanks where there are irregular and uneven beds, the water should of course be bailed out before the filling is begun. A large number of tanks could in this way be levelled in a few years at a comparatively small cost.

A large number of tanks and excavations are fairly deep in some parts, especially near the middle, and shallow towards the banks. The shallow parts retain water for a few months after the rains and gradually dry up. These shallow parts, especially when pools are left in them, are much favoured by mosquitoes for laying eggs in. In these cases when the process of filling up the tank cannot be carried out at once, it may be taken in hand by stages. If the bed of the shallower parts were raised a foot or so and properly levelled, these parts would cease to hold water. The bed of the deeper parts may then, when funds are available, be raised to the level of the shallower parts. Deep waters do not as a rule favour the breeding of mosquitoes.

There is no sanitary objection to filling up of hollows and low-lying ground with dry refuse for the purpose of reclaiming the land thus used, provided these places are remote from human habitations. Tanks, wells, low-lying ground and borrow-pits near houses, should never be filled up in this way, nor should refuse ever be deposited near a source of water-supply. As each day's refuse is added in the places mentioned above, it should be covered with a few inches of fresh earth to stop smells arising, and to prevent flies from breeding in the refuse.

No place where rubbish has been deposited should be built on for a number of years. Such "made-soil," unless all the organic matter in it is completely disintegrated, is unhealthy as a house site.

Nothing grows on fresh rubbish heaps. Putrefaction and fermentation occurs in tanks filled with refuse. No amount of earth prevents this if water is not first removed and further accession of water prevented.

I.—Night-soil and its Disposal in Cantonments.

Importance of early disposal.—It is a matter of the utmost importance to health that all discharges from the bowels and kidneys should be got rid of as speedily as possible. We shall see that this is one of the gravest and most difficult questions in the practical sanitation of large cantonments and of standing camps in the field. In billets in villages, where houses are more or less scattered, the community small, and the force resort to night-soil trenches in the fields to perform the offices of nature, the question of removal of human refuse is, perhaps, associated with fewer evils; but in the case of large cantonments and in standing camps on field service, the disposal of excreta becomes literally a matter of vital importance.

The greatest danger from excreta is the fact that with large masses of troops some are almost certainly suffering from one or more forms of infectious disease, or have recently recovered from such diseases, and their excreta contain the germs of these diseases. In the case of ordinary dejecta, not specifically infective, it is not until the ordure begins to decompose that it is injurious. The period when this decomposition sets in varies with the season of the year, and particularly depends upon whether liquid excrement has mixed with it or not; in this latter case putrefaction rapidly ensues and offensive ammoniacal and carburetted hydrogen gases are given off, especially in the hot weather. All excreta (fæces and urine) should therefore be removed from the neighbourhood of barracks or incinerated as expeditiously as possible, and before this putrefaction sets in.

Chief diseases arising from night-soil.—Many of the diseases that occur in the large towns of India are due to imperfect removal of the waste matters of the inhabitants. Foremost amongst these are *cholera*, *typoid fever*, *dysentery*, and *epidemic diarrhœa*.

Cholera.—With regard to cholera, we have had enough proof without insistance on the point here to show that the poison of the disease is contained in the discharges of persons attacked (see p. 105). If these discharges, therefore, gain access to the alimentary tract, either by mixing with drinking water or accidentally finding their way to food or in any otherway, they are liable to bring about cholera. It behoves us to thoroughly destroy, by *disinfection*, whatever passes from the bowels or the vomit of such cases, and then have the material cremated, the alternative being deep burial at a considerable distance from barracks, camps, wells, and water-sources.

Typhoid fever.—*Typhoid* or *enteric fever* does not affect the people of India to the same extent that it does the young Europeans coming to the country. A large number of young British soldiers are yearly attacked with this disease; in fact, it causes among them three times more deaths than any other disease. The poison of typhoid fever is a specific one, and is contained in the discharges of patients (urine and fæces) suffering from that disease.

Many of us know, from personal experience, that *diarrhœa* may arise from foul emanations from filth collections. *Dysentery* likewise may be caused by the microbes of that disease from human excreta.

Diphtheria and sore-throat.—Occasionally in India (although much less frequently than in Europe) *diphtheria* is brought about from the same cause; in this case also there is a definite bacillus which attacks the throat. Various forms of *sore-throat* may also be caused by the emanations and germs given off by putrefying fæces.

But these are not the only effects. If we are constantly surrounded by such accumulations of human ordure we are obliged to inhale the products of fæcal fermentations; these, in their dilute form bring about no sudden change in health, but they produce a subtle influence far more dangerous because less felt: they bring about a lowering of the vital powers gradually, thereby rendering us less able to withstand the effects of other disease causes.

Systems of night-soil removal in use.—In most parts of India for want of a sufficient supply of water or from the absence of natural facilities, such as the want of a proper fall, the removal of sewage by water either cannot be adopted, or it is very expensive and difficult to carry out. Under any of these circumstances one of several things occurs—either (1) the material accumulates around dwellings, or (2) it has to be removed daily, or at a few days' interval, by means of carts or by manual labour by one of the *dry methods*, or (3) the excreta are incinerated *in situ*.

Pail system.—The pail system in one or other of its various forms is in general use in Indian cantonments. It implies really the use of a movable cesspool, consisting of a pail or pan. The pail is used alone in the latrines of Native troops, some liquid deodorant or disinfectant is put into it in the case of European troops. As a rule the pail is emptied daily or twice a day.

A description of what is done in many large cantonments will enable us to understand the working of the pail system. There is a conservancy establishment consisting of scavengers and bullock-drivers; there are also a certain number of water-tight iron night-soil carts, to convey the night-soil away from the latrines. Each cart has a certain area of the cantonment allotted to it, with its driver, and scavenger. These men are responsible for carrying out their work properly in the given area.

The latrines are placed in various parts of the cantonment and consist of either galvanised or corrugated iron, or of masonry or brick-sheds, with compartments. Each compartment has a recess in which an iron pan or bucket fits. This bucket is emptied morning and evening, into what we call the "intermediate" receptacle; these are elongated iron, cylindrical-shaped utensils having water-tight iron covers. A sufficient number of these is attached to each privy to contain the contents of the pails, so that the latrines are always more or less clean. The pails are emptied into iron receptacles from which it is in most cases again transferred into iron carts at the latrines. The night-soil is then conveyed to, and deposited in trenches (superficial or deep), or on prepared soil situated remote from all houses, wells, tanks, and water-courses.

The pans, receptacles, carts, and latrines are regularly tarred; and lately in many cantonments a quantity of disinfectants has beeu used to prevent smell, to kill or delay the multiplication of disease-germs, and to prevent the breeding of flies. The plan above sketched, more or less modified, is that which is adopted in most cantonments in India. It is an exceedingly expensive and laborious one.

In some places carts are not used. Then the intermediate receptacle which is filled from the pails or pans used in the latrines is carried on the head of one man, or where of large size suspended on a pole between two men; or two of the pails actually used in the latrines are suspended from the ends of a pole and carried on the shoulder of one man—the receptacles and pails in all cases having water-tight covers. In both these latter cases the contents from the receptacles or pails are discharged direct into the night-soil trenches.

When removal has to be carried out, removal of the pails actually used in the latrines is by far the best way of doing this, one man carrying two pails at the ends of a bamboo slung across the shoulder. In this case the size of the pails should be uniform and at least one cubic foot in capacity, and they should be provided with properly-fitting covers.

In connection with latrines for Native troops and Native inhabitants of cantonments, if trenching of the night-soil is to be adopted, it is preferable to remove the solids and liquids separately; and arrangements may be made at the latrine for keeping them separate. If the trenching ground is any distance the jolting of the carts causes mixed excreta to assume a viscid glutinous form, which makes it difficult to clean the carts.

To work such a system of removal as this in its perfected form, it is necessary to have a good conservancy staff, and a sufficient number of carts and latrines. One public latrine of twelve seats is sufficient for 250 men, or one of five or six seats per company.

Dry-earth system.—In this plan dry earth is used as a deodorant and disinfectant in the privy pans each time the privy is used. About three pounds of earth are used on each occasion. This is the method that was in use in Indian cantonments for many years. During the last five or six years it has fallen into disfavour, and there is abundant evidence to show that it was in all probability a potent cause of endemic typhoid fever and probably of dysentery. The germs of specific diseases such as dysentery, infective diarrhœa, and typhoid fever, can all live, and, at any rate for a short time, thrive, in this bed of earth, whilst the latter fosters the formation of the ova of flies which are also capable of conveying the infection of these diseases. The place of the dry earth is now being taken by a liquid disinfectant (diluted crude carbolic acid or perchloride of mercury solution being probably amongst the best), which is always kept in the pans. This not only kills germs but militates against the development of flies.

Lt.-Col. Glenn Allen's system for cantonments.—Lieutenant-Colonel GLENN ALLEN, R.A.M.C., in the July 1906 issue of the *Journal of the Royal Army Medical Corps,* states that the most economic and most generally applicable conservancy method we can adopt in India to protect the British soldier from typhoid fever is:—

1. To abolish the dry-earth system entirely in the latrines.

2. To substitute a weak antiseptic, *viz.,* crude carbolic acid, half an ounce to the gallon.

3. The pans to be filled two-thirds full every morning with this solution and emptied when requisite. The very weak solution of carbolic acid is simply to prevent the access of flies, to counteract putrefaction, and lower the resistance of sewage bacteria.

4. Empty the pans directly into the chamber of a special steriliser thus doing away with the objectionable receptacles.

5. The steriliser to be placed in the space behind the latrines.

6. To abandon all shallow trenching, whether on the Allahabad or the THORNHILL pattern. The trenches to be 3 feet deep and to be filled in when about 12 inches from the surface.

In the event of any form of pail system being used it is necessary to know the quantity of human excrement that will have to be dealt with to estimate the number of cylinders and carts required. Each person in a mixed European and Native force discharges on an average 8 ounces of ordure and about 50 ounces of urine. In standing camps about 20 ounces of the urine would probably be discharged in the night urinaries and not carted away. Roughly, there would be 40 ounces per man to deal with, which, with a brigade of 4,000 would mean 1,000 gallons of sewage per diem. As ablution after use of the latrine is practised by Native troops, an additional 40 ounces per man has to be calculated for them. The carts are usually 60, 80, 100, or 150

gallons capacity, and the cylinders 6 gallons, from which the numbers needed may be easily estimated. The carts may be able to make two or three trips in the day. The lowest estimate under the most favourable circumstances would be one 60-gallon cart per unit, with one spare cart per brigade. The difficulties in connection with this form of removal in Indian Frontier warfare are so numerous that it will very rarely be employed except at the base and on the lines of communication.

Latrines—*Fixed metal latrines.*—For European troops permanent or fixed latrines of some kind are used in all cantonments. These are usually constructed of burnt bricks or masonry, and the forms in general use are not such as to meet with general approval amongst military sanitary officers. The fixed metal latrines employed in most large towns in India are much more sanitary. There are many patterns of these metal latrines which vary somewhat in details of construction. In these fixed metal latrines the roof should be water-proof and extend beyond the area of the plinth, the latrine should consist of a raised platform or plinth of stone or brick covered with cement. The latrines should be placed at a distance from barracks and bazaars or where they will not be a nuisance, and yet be convenient for use.

The floor should in all cases be of cement and water-tight: and the platform for squatting on of iron, or brick set and faced with cement, or glazed earthenware, and for sitting on of wood. The compartments are separated by corrugated galvanised or sheet iron fixed in an angle iron framework, similar sheeting surrounding the latrine and forming its roof. Pans of suitable pattern are placed beneath the seat.

The latrines must be protected from flood and rain water. If this is done the amount of material to be dealt with is always easily estimated for; if not, the whole system may become a terrible nuisance and a source of disease. In permanent latrines this is done by raising the ground on which the latrines is to be placed and causing the surface of the ground, from the outer limits of the floor of the latrine to slope away from the latrine, and by providing a roof which will protect it efficiently in every part against rain.

Movable metal latrines.—Movable metal latrines are specially applicable to Native regimental lines where there is abundance of spare ground. Those of what is now known as the "Delhi Durbar Pattern" are largely used in Indian cantonments for regimental bazaars and Native troops. They are exceedingly simple in construction. They consist of compartments enclosed by corrugated iron sheets set in a framework of angle iron The ordure is received into metal pans. The user squats on a platform made from sunburnt bricks, stone, or iron. The position of these latrines shonld be changed at least once every fortnight, and the site they occupied dug up for half a foot or so and raked, so that all parts of the recently occupied area is thoroughly exposed to the disinfecting action of the sun. The site should not be used again, if possible, for three months.

These latrines are clean, easy to work, and free from the nuisance associated with all the older forms of fixed brick and masonry latrines. With these latrines the daily removal of the excreta is carried out in the same way as in the larger fixed latrines. They cannot, however, be compared as regards facility for cleaning with the fixed metal latrines described above.

Trenching of excreta—Selection of site for trenches.—Low-lying land subject to flooding or water-logging, or not drained properly during the rains, should never be selected. The best site is well drained high land, with a loamy soil, situated to leeward of the cantonment, screened from the public, and not too remote. It should always be where at least two trips may be made during the 24 hours. When moderately near at hand it prevents the drivers emptying the pails or carts on the road side, into ditches, or other tempting spots. If no elevated site is available, the land should be raised and thoroughly drained.

Provision should also be made to prevent higher ground around draining towards the trenches, if necessary, by intercepting drains around the site. The soil excavated from these drains may be used to elevate the trenches. For such elevation earth may be excavated from a neighbouring plot, and so forming a sort of tank, the water draining into which will subsequently be useful for washing the carts and pails, and for irrigation purposes during the dry season. If this tank breeds mosquitoes it should be pesterined or kerosined.

Before describing the methods of trenching excreta in use in various cantonments, I will give a description of the method which is carried out in several large towns and to which, if carried out under strict supervision, there are few objections.

Preparation of the trenching ground.—The ground should be levelled, drained, and divided into 12 equal plots, these being intercepted by metalled roads and pathways for carts and coolies. Each part should be of sufficient size to accommodate a month's excreta. The plots will vary in size according to the population of the cantonment or part of the cantonment for which the trenches are required. The amount that each trench takes will vary according to the depth of sewage put into it. This latter varies from two to six inches, according to the depth of the trench.

Area required and description of trenches.—There are two kinds of trenches in use:—(1) *Shallow*, 2 feet wide and 9 inches deep, with a wall of earth 1 foot thick between the rows of trenches; into this shallow trench 2 inches of night-soil is deposited; (2) *deeper*, 2 feet wide and 12 to 18 inches deep, with a foot wall between each trench. It receives 8 inches of night-soil.

The area required for the shallow system is 180 square feet per day per 1,000 persons. This area includes the trenches and ground between the rows of trenches. Multiplying this by the days in the year, the area required to allow each day's area remaining fallow for one year is 65,700, sq. feet, which is about 1½ acres. The actual area required for 1,000 persons with the deeper trenches would be only one-fourth of this, or a little over one-third of an acre. These are maximum allowances to permit of 12 months' rest of the soil. This liberal area is always preferable for towns, stations and cantonments.

Filling of trenches.—This is done by the scavengers emptying the pails directly into the trenches. If carts are used they should not be emptied at one end of the trenches and the sewage then raked along to the other end. This creates an abominable nuisance It is preferable to empty the contents of carts into pails at the trenches, these being carried to the trenches and deposited one by one along the trench. The trenches for one day should be in one long line and not in a parallel series—the plot for the month being just sufficient for one trench a day. The earth used for covering the deposited night-soil should be heaped up and not merely made flush with the surface, as the heaping up allows for the sinking in of the night-soil which is inevitable. If hollows form during the rains they may become a great nuisance (J. W. SIMPSON.)

" **Cultivation of trenching grounds.**—The trenches should always be cultivated after the night-soil has rested three months. The ground should be ploughed up and sown with tobacco, rye-grass, sugarcane, etc. After the first crop the plots are ready for vegetables of all kinds which may be cultivated and sent to market without any risk of being causes of disease through their production on the trenching ground." (J. W. SIMPSON). In dry places with dust-storms, it is necessary to irrigate the trenches to prevent the night-soil hardening and being blown about as dust.

The chief drawbacks to the trenching system are its expense and the difficulty of ensuring a sufficient amount of responsible supervision.

Trench system used in Indian cantonments.—One of the general methods of trenching night-soil now adopted in Indian cantonments is that which originated at Allahabad, and is known as the "shallow trench system."

The principles comprised in the shallow trench system are the conversion of organic into inorganic matter, and the best means for utilising this change for the purpose of practical farming. The object arrived at is the total destruction and nitrification of the sewage in the shortest possible time, so as to enhance soil production of vegetation and enable the soil to be used as a trench again as expeditiously as possible.

Inapplicability of this system in camps.—Such shallow trenches as these should never be used on field service. Neither of the objects aimed at is ever called for, whilst there are many ways of specifically contaminated ordure superficially placed finding its way to camps and infecting their inhabitants. On the other hand, in the deep trenches used on field service, the object is to bury the night-soil in such a way that it cannot affect the health of the troops immediately or in the future.

Shallow trenching of night soil as conducted at Allahabad, Lucknow, and many large cantonments in India, and trenching after the THORNHILL system, make the undertaking at any rate a financial success, but there is not a unanimity of opinion as to either of these methods being hygienically perfect or free from risk to the health of the troops. It is not altogether prudent to rely upon the soil (an agent the physical conditions of which are liable to such great variations) to convert the often dangerous sewage into harmless and valuable manure without danger to the health of the community.

A considerable amount of discussion has arisen regarding the Allahabad shallow-trench system, which has by some been condemned as liable to lead to disease, and by other authorities been eulogised as the entire solution of the problem of the final disposal of night-soil in India. As there appears to be some misunderstanding as to what this system is, and as in several stations the original method has been deviated from considerably, one gives here a description of it by the officers who designed it, Majors A. C. WILLIAMS and D. J. MEAGHER.

"**Method of disposal.**—The superficial area of each space required for the contents of a Crowley pattern filth cart, containing 60 gallons, has been found to be 80 sq. feet. The area required per cart of other dimensions can be readily calculated on this basis. The most suitable dimensions for this 80 sq. feet are 16 feet long and 5 feet broad. Three inches of the top surface of this space are removed and placed on the embankment of the plot, nearest to which the first line of trenches is dug. The land is, of course, first *gahta banded* (divided into plots by low embankments) and the trenching begun close to the embankment. The subsoil thus exposed is well pulverised to a depth of at least 9 inches. When the contents of the cart are tipped into the centre of the trench, the liquid matter rapidly soaks into the loosened soil, while the solid excreta remain on the top. This solid matter is less than $\frac{1}{8}$ inch thick. Three inches of earth are then removed similarly from the top of the next trench, which is dug parallel to the first, with no intervening space. The soil dug from the second trench is thrown over the night-soil in the first trench, and the process repeated. The above generally applies to cantonment filth carts which contain a large quantity of urine and cook-house water, the night-soil comprising only about one-third of the contents. The municipal filth carts, employed in bazaars and cities, on the other hand, largely contain solids, as,

owing to defective sanitary arrangements, the liquid is not collected. In this system, therefore, there is no necessity to pulverise the bottom of the trench.

"**Supervision simplified.**—It has frequently been argued as an objection to the surface form of disposal that it has been difficult to supervise. Those who thoroughly understand the method are agreed that it can be more effectively supervised than any other system. All that the overseer or supervisor has to do is to see overnight that sufficient spaces, according to the daily number of filth carts, have been prepared; and he can easily ascertain if the soil has been sufficiently pulverised by thrusting his stick into each pit. He need not return till the following evening, when he should see that the areas or spaces prepared have been properly filled and covered, and that sufficient trenches for the next day are dug. If he should neglect to do this, the sweepers will naturally empty two carts into one space to save labour in digging.

"**Suited to every season.**—Experience teaches it is by far the best known system for both wet and dry seasons. It has been carried out at Allahabad for fourteen years without any hitch, and on various descriptions of soil, including stiff clay, black cotton, and sand. At Allahabad the success achieved is mainly due to the farm having remunerated the cantonment sweepers and beldars, engaged in this work; and unless this is done elsewhere, it will not be possible to ensure the work being carried out satisfactorily and in accordance with the instructions given above.

"***Juar*** **or millet to be sown with** ***dub.***—Crops can be successfully grown immediately after trenching, and even in the cultivation of grass the first crop is greedily eaten by cattle. Such land should be put down to grass without ploughing. As regulation demands the sowing of a *sorghum* crop on land trenched with night-soil, this should be done without disturbing the soil and exposing the newly buried night soil. At Allahabad *sorghum* and grass are sown together as described below. It is first sown broadcast with about 7 pounds of seed to the acre. The chopped *dub* is then sprinkled over the seed and the whole tightly covered with earth.

"**When the crop should be cut.**—It will be found that these will grow together, and when the *juar* has attained a height of about 4 feet and the grass a height of about 1 foot, the whole should be cut together and issued green to horses, mules, bullocks, pigs, or milch cattle. If allowed to grow higher the grass will suffer owing to the excessive heat and want of ventilation caused by the *juar*. Both crops will shortly re-appear, and should again be cut at the same height. The third crop will contain very little *juar*. About six cuttings are obtained during the year, with a total outturn of from 600 to 800 maunds. Land thus trenched with cantonment night-soil will require re-manuring after five years, while land similarly treated with city night-soil will last fully

seven years. If necessary, and specially where the space available for trenching is limited, the ground can be treated every second or third year.

"**Advantages claimed.**—The system of surface disposal enables about seven times as large an area of land to be manured as could be done under the deep trench system with the same quantity of manure. Such land rents readily at from Rs. 20 to Rs. 45 per acre, and this means that it is possible to raise the revenue of cantonments under this heading very considerably.

"**Rapid decomposition.**—Rapid decomposition in the shallow trench system is due to the excreta being exposed (with a protection of only 3 inches of earth) to the action of the sun and atmosphere. Considerably less than 3 inches of earth would suffice to keep down the smell, but as such trenching is carried out on very poor or barren land with little or no depth of soil, it is beneficial to the land to have 3 inches over the manure, thus adding to the depth of the soil.

The cost of this system of manuring cannot be fully calculated, as the cantonment night-soil is usually obtainable free, the only expenditure to be incurred would be as follows :—

	Rs.	a.	p.
Extra remuneration to cantonment conservancy, including overseer, per acre ...	30	0	0
Seed per acre	0	6	0
Labour for sowing and covering ...	12	0	0
Total ...	42	6	0

After many trials and experiments of the various methods of disposing of night soil from a sanitary point of view, the method here described has been found to answer best, while at the same time, from an agricultural point of view, it is far superior to the old methods of deep trenching."*

Objections to the Allahabad shallow-trench system.—Many objections have been raised against this shallow-trenching, the chief being—

(1) That it spreads typhoid fever through specifically infected dust, or by washing bacilli of this disease into water-courses during the rains. Investigations carried out in military stations where it has been conducted on a large scale, especially in

* Majors A. C. Williams and Meagher, *The Farm Manual*, pp. 21–23.

Lucknow and Allahabad, do not lend support to this objection, in point of fact there has been a decrease of the disease in at least some of these stations. In all probability other factors have combined to bring about an increase of this disease in some stations especially the typhoid fever "carrier."

(2) That flies are propagated in the trenches and through them disease disseminated. In all probability this is the case.

(3) That the trenches are a great nuisance from the offensive smells arising from them. This is an unfounded objection when the system is properly supervised. One has been over the trenches at Lucknow, Bareilly and Allahabad during different seasons and could not complain of the smell.

(4) That during the hot weather fermentation of the excreta gives rise to the formation of gases which displace the thin layer of covering earth and exposes the fæces to the open air. This occasionally does happen, but can be readily remedied by the addition of further earth to the parts where any bubbling is observed on the surface.

(5) That during the monsoon the system breaks down owing to the flooding of the trenches. The heavy rains of the monsoon season doubtless militate against the system, but any serious results are obviated by digging the trenches slightly deeper.

Notwithstanding the many points in favour of the shallow-trench system, it cannot be considered free from the possibility of disseminating sewage-borne diseases, and one personally is of opinion that the system of trenching described on pp. 287—288 is much less liable to be associated with the spread of these diseases.

Trenching grounds have on several occasions in India been accused as being sources of typhoid fever. There is, however, no evidence to show that when a trenching ground has been properly selected, elevated, drained, situated to leeward of inhabited places, well managed and supervised, it has been a source of typhoid fever.

Flies in latrines and trenching grounds.—Swarms of flies over a trenching ground is an indication of bad management. The ova of flies deposited in latrines are often hatched in the trenching grounds. Flies infest neglected latrines and are specially favoured by an unclean, insanitary, and badly managed pail system. Personally one considers that the dry-earth system should be permanently banished from all municipalities, towns and cantonments. One has no doubt about its being a source of bacillary dysentery, infective diarrhœa and typhoid fever.

All conservancy work connected with removal of night-soil to trenches should be carried out in the daytime when supervision is possible and the sun can assist in reducing any nuisance caused. Night work cannot be properly supervised, and the darkness offers temptations to the workmen to deposit excreta in places not intended for the purpose.

Night-soil poudrette as manure.—In certain stations in India the night-soil is made into poudrette which is sold to farmers as manure.

In Poona, the poudrette is manufactured by mixing the excreta with ashes resulting from the burning of dry refuse. Beds 18 feet square and 1 foot deep have a layer of ashes 1 inch deep, spread at the bottom, the night-soil to the extent of 4 or 5 inches is poured on the ashes and this again is covered with another inch of ashes. In the dry season this is conducted in the open air and the mass is allowed to remain exposed to the sun for 24 hours. In the rainy season it is carried out in sheds, and the mass is not touched for three days. Then the night-soil is raked and thoroughly mixed, and another layer of ashes one inch thick is put on, and the whole is left to itself for three days in the dry season and eight days in the rains. In the dry season the mixture is next taken out of the beds, exposed on prepared ground to the sun for 24 hours and then stored for sale. In the rainy season the drying has to be effected under cover and the whole operation may take a fortnight, whereas in the hot and dry season it is completed and the manure ready for use in four days.*

In Hyderabad (Deccan) we dealt with part of the sewage in this way for some years, and one's personal experience of it was that it is laborious, and during the rainy season difficult to manage without creating a nuisance. It was also expensive, chiefly because it was difficult to get farmers to purchase the poudrette, although we found no difficulty in selling manure that had been trenched for six months.

"In very hot and dry stations the drying could be carried out in shallow pans, or on a prepared surface, the sun and air being the natural agents employed for evaporation purposes. Where there is heavy rain this process is expensive as it has to be done under cover by the aid of fuel." In the dry stations of the Punjab and Sind it should be successful and inexpensive.

Septic tank system.—The septic tank or liquefaction process consists of permitting the crude sewage to pass slowly—usually the time allowed is 24 hours, but this is altogether too short—through a closed tank from which light and air are excluded. During this passage the solids become liquefied, chiefly, it is considered, through the action of anaerobic micro-organisms; the sewage on leaving the tank is made to pass over clinker, coke, breeze or other filtering medium, the effluent being allowed to pass into streams or rivers.

* W. J. Simpson, *Tropical Hygiene*, p. 239.

The tank roughly imitates the action of a filter-bed in water-works the principal agency of which is the action of micro-organisms lying on the upper layer of sand in the filter.

In inland towns, municipalities, stations and cantonments, septic tanks in association with the pail system have not so far been tried on a sufficiently large scale to enable us to form any definite opinion as to their value or applicability in the sanitation of cantonments. They have been tried in a few stations and the reports are conflicting.

Destruction of excreta by incineration.—In Indian cantonments three systems of getting rid of excreta are practised:—Trenching in either superficial or deep trenches, incineration, and sterilisation. The trenching is the same as that already described. A large number of Indian cantonments are being provided with *incinerators*, into which the excreta are thrown directly. As soon as the pans in the latrine have been used they are at once brought to the incinerator and emptied into it. This does away with both the conservancy carts and the intermediate receptacles or metal cylinders in which the excreta used to be collected between the visits of the carts. The main object aimed at in these cantonment incinerators is to once for all do away with the risks associated with trenching, and completely destroy all cantonment ordure practically *in situ*. In all cases the latrines of the cantonment are divided up into groups, each group being connected with one incinerator, into which all the excreta are conveyed direct from the latrine pans. Where the latrines are remote from one another a small incinerator may be used for each. The fuel employed is stable litter, road sweepings, bazaar dry refuse, leaves of trees, etc.

Attached to each incinerator is a shed for storing the combustible refuse and keeping it dry during the rainy season, and a hut for scavengers, one of whom is always on duty attending to the incineration.

There are various patterns of these incinerators, those in most general use at present are RAITT'S or the *Rawalpindi pattern* and HUNT'S or the *Mhow pattern*, both of which are *open incinerators*; and the *Sialkot* and COOK-YOUNG patterns, which are *closed incinerators*. The Mhow pattern is considered to be an improvement on the other forms of open incinerators.

The Mhow pattern incinerator, which is circular in shape, is constructed of rod iron bars fitted up on 1 inch and $\frac{1}{4}$ inch angle iron rungs at the top and bottom, with iron sheeting around the lower part of the perimeter; it has a covered chimney in the centre to create a draught through the furnace, the draught being regulated by four doors placed at equal distances around the perimeter. The bottom of the incinerator is made of iron bars $1\frac{1}{2}$ inches apart, upon which the dry refuse is thrown. When incineration is in full swing the ashes

accumulating between these bars is set free by raking with an iron rod. The incinerator may be covered by a circular sloping shed consisting of iron sheeting supported by bars of angle iron.

In using the incinerator the body is filled with dry refuse fuel to within a foot or so of the top of the chimney. This is lighted from the bottom and from the side doors, and allowed to burn for from three to six hours, according to the size of the incinerator. When there is a complete glow in the furnace, the contents of the privy pans, liquid and solid, are emptied upon the furnace, and lightly covered with fresh fuel and burnt to an ash. The ordure is to be distributed uniformly all round.

An incinerator of this pattern 7 feet in diameter will dispose of 125 gallons of liquid and solid ordure in 24 hours, with a consumption of 45 cubic feet of litter of fairly combustible quality. When recharging this incinerator it is only necessary to rake out the ash with long iron rods and rakes kept for the purpose, and level the still glowing residue upon which a fresh charge of fuel is located, allowed to burn freely, and then another lot of ordure is added as before.

Raitt's or the *Rawalpindi pattern* incinerator is much the same as that just described except that they have hitherto been made larger, the general size being from 10 to 13 feet in diameter. They are circular in shape, made of iron hooping radiating from a centre, and attached to a framework of angle iron at the circumference.

The chief objections to these open incinerators at present are connected with obtaining sufficient dry refuse for the complete combustion of ordure, dampness of the dry refuse during the rains, even when drying sheds and roofs are provided to the incinerators, the unpleasantness associated with the fumes from burning damp refuse during the rains (which could be partly overcome by a higher chimney), the difficulty of regulating the combustion, the effect of high winds in blowing ashes and débris from the charged incinerators (to some extent obviated by wind screens), the fact that they have some trouble in dealing with the urine, absence of any arrangement for consuming the smoke created, and the amount of repairs required. To be economically worked the fuel should consist of dry refuse, stable litter, road sweepings, bazaar refuse, fallen leaves of trees, etc., which are not always easy to obtain, store, and maintain in a dry state in sufficient quantities to keep the incinerators working regularly throughout the year. One has no doubt that all these difficulties will in time be removed.

The Sialkot incinerator.—This is a pattern in use in some cantonments in Northern India, and is designed to effect the complete combustion of all latrine excreta and ablution water under a closed incinerator. The body of the incinerator is composed of bricks, which should be of the best quality and set in lime. Angle iron is used for

the bars which form the grating, which are fixed at a height of 12 inches from the floor, there being a clear space between each bar of 1¼ inches. The doors for the large incinerators, and wind screens and roofs of the small incinerators, are made of sheet iron in an angle iron framework. The cover or door fits into the openings in the large incinerators and is removed as required. The furnace is fed from above. The draught enters from four openings made below the grating. The inside of the furnace is dome-shaped to avoid angles and enhance the draught. The larger pattern is used for regimental bazaars and regimental latrines. In them the chimney is constructed over the centre of the furnace, the opening for charging being on the dome just above the beginning of its curve from the lateral walls.

In these also the privy pans are emptied directly into the incinerator, and as soon as possible after the pans have been used. This obviates the gathering of flies. A two-roomed shed is constructed in the vicinity of the incinerator, one room for storing refuse and the other for the scavengers who attend to the incineration. It is stated that the ash left after incineration is a valuable manure for heavy soils. The chief advantages claimed for this incinerator are—durability and simplicity, economy in construction and subsequent working, independdence of meteorological influences, the litter used cannot be blown about which is one of the defects of the Raitt and Mhow pattern incinerators, the fire is easily lighted, and the process of feeding and maintaining the furnace in action is very simple.

It may be considered that all these incinerators are still in the experimental stage, and one is of opinion that when perfected the ultimate outcome will to a large extent solve the problem of dealing with night-soil in cantonments, and comparatively small communities when health and not profit is aimed at.

The *Cook-Young* incinerator is a square brick structure which also uses dry refuse for incineration of the ordure. The bed for the refuse is formed of iron bars. Arrangements are made at the sides for draught, and the fumes are carried away by a chimney in the roof. The door is also in the roof which is constructed of sheet iron. For dealing with a small amount of ordure such as that of a regimental hospital or station hospital, this is a handy incinerator. It may also be used for the grouped latrines of detachments of men up to 250 or 300. It deals with both solid and liquid excreta.

Another form of night-soil incinerator is the following. It consists of an elongated rectangular brick chimney 20 feet in height, broad below, narrow above ; at the bottom of the chimney is a grate formed of parallel thick iron bars about 1½ inches apart, stretching from one side of the base of the chimney to the other. About 3 feet above the grate is a window in one side of the chimney, approached by brick steps. The upper surface of the grate is thickly packed with dry

refuse and the sewage is shot on to it. The incinerator is started by wood fuel, lighted in a space below the grate. After each day's sewage is incinerated, the ash is raked out and a fresh quantity of dry refuse and excreta added. The excreta are carried in pails of one cubic foot capacity by scavengers, two slung on to the ends of a bamboo, being carried by each man from the latrine and thrown directly from these pails on to the incinerator. In two stations where one worked this form of incinerator the daily consumption of wood fuel, besides 35 cubic feet of dry refuse for the excreta of 850 men, was 3 maunds. One incinerator was sufficient; it was in one case 400 yards from the barracks and in the other 450. There was practically no nuisance attached to the working, except occasionally slight trickling of the liquid part of the ordure on to the ashes; when this happened ashes and all were returned into the incinerator. This is the least expensive method of dealing with the night-soil of a cantonment one is acquainted with. There is nothing to get out of gear, and the only recurring expense was that of repairing or renewing the iron bars of the grate. In the instances above quoted, the urine was to a large extent collected separately, conveyed in the same kind of pails and trenched. The capacity of the incinerator was limited to dealing with 15 cubic feet of mixed ordure in the 24 hours, about 7 cubic feet of which consisted of solid fæces and 8 of urine. It will be seen that this is a closed pattern incinerator, and that it is very much like that of the Sialkot pattern.

In practically all inland officers' bungalows the bath-room contains a *commode*. When used the sweeper at once removes the pan and empties the contents into a cylindrical pail or other receptacle, kept in a special shed in the compound. The contents of the cylinder is removed by the cantonment conservancy establishment. It is very desirable that some form of disinfectant be kept constantly in the pan of the commode, so that all the excreta are to some extent, at least, disinfected. For this purpose one or other of the following (properly diluted) is very useful—saponified cresol, cresol, cyllin, lysol, creolin, izal and Jeyes' fluid.

The bath-room water should not be allowed to simply trickle through a hole in the wall on to the surface soil outside. It should flow through such a hole (covered with perforated metal or close-meshed wire-gauze to exclude snakes, rats or other vermin, flies and mosquitoes) communicating with a tubular pipe which opens into a branch drain running into the general house drain or into a movable metal receptacle

SANITATION OF CAMPS.

A.—Camp Sites.

Apart from barracks in cantonments the habitations of troops may consist of tents, huts or billets. Frequently in modern warfare it is necessary to bivouac; sometimes, in the presence of the enemy it may be necessary to do so for days or even weeks together.

The more important points in connection with the sanitation of camps are—the site, disposition of tents, water-supply, kitchens, latrines, urinals, disposal of refuse, ablution places, arrangements for drying of clothes, disposal of dead carcases, slaughtering-place and site for cemetery.

Regulations regarding selection of sites.—Regarding the selection of habitations and sites for camps, huts, etc., on field service, the Regulations are :—"The P. M. O. of the field force (or his deputy) will accompany the Quarter-Master-General (or such officer as the latter may appoint) in selecting buildings for the troops. He will examine into the sanitary conditions of such buildings and will advise the Quarter-Master-General on the same. He will point out in his reports any defects requiring remedy and state the number of troops or sick which can be safely accommodated in the buildings. He, or his deputy, will accompany the Quarter-Master-General (or such other officer as the latter may appoint) in his inspection of sites for encampments and will give his opinion on the salubrity or otherwise of the proposed position, with any recommendations he may have to make respecting drainage, preparation of the ground, distance of tents or huts from each other, number of men to be placed in each hut or tent, state of cleanliness of surrounding ground, ventilation, water-supply, position of latrines and slaughtering-places, cleansing, and the disposal of refuse; burial of the dead; disposal of carcases of animals; and on all matters likely to affect the health of the troops and followers."

Sites are chiefly regulated by military considerations.—Once within the enemy's country the site for camps will be largely influenced by strategical, tactical, or other military exigencies; nevertheless, experienced generals fully appreciate the necessity of attaching due weight to sanitary considerations. The history of Indian warfare shows that in the absence of special military objections, generals have usually selected the healthiest available sites for their force.

Principal Medical Officer's duty when unhealthy site has to be occupied.—It may at times be necessary to weigh the question of the effects of an insalubrious site on the Army as against the advantages of a victory gained in such a locality, and it may happen that the sanitary adviser with the force will have to place a statement of the risks from disease under the circumstance, before the General Officer Commanding, under whom he is serving. The latter is the responsible officer, and it is in justice due to him that he should have all the chances of success or the reverse before him when deciding as to the course he will pursue.

Most suitable sites.—If we have a choice of sites the one to be selected would have a permeable surface soil and subsoil, which does not receive and hold the surface water draining from higher

ground, which has a moderate fall for drainage, not covered with vegetation, and not adjacent to marshy ground An ideal camping ground would be one with a gentle slope, on even ground near the summit of rising ground, on a gravelly or sandy soil, near a mountain stream which has no villages on its banks for some miles above the site of the camp. The higher the ground, especially if it slopes all round, the better the drainage of the camp, the fresher the air and the freer the ventilation.

If a marshy area must be occupied we should select the highest plot around, and, if possible, have a belt of trees between the camp and the marsh. Where a force has to march through and remain in malarious districts, the advisability of providing it with mosquito nets should be considered. This has been done under regimental arrangements in many cantonments, and could readily be carried out in the same way on field service in malarious places.

The neighbourhood of recently ploughed fields, rice-fields, marshes, undergrowth, are to be avoided, as in such places mosquitoes and other insects are certain to be present in swarms during most parts of the year.

Abandoned camping grounds should not be occupied if they can be avoided. Old camping grounds are, as a rule, infected by previous occupation—the soil is often specifically infected by the germs of communicable disease; some previous occupants may have been "carriers" of certain diseases, whose discharges may infect new occupants. The sites of our old camping grounds are known by the raised positions of the latrine trenches, tent drains, kitchens, etc.

Sites to be avoided.—Banks of rivers, especially those which overflow periodically, and those which are drying up and contain stagnant pools, are unhealthy, as are also those of all marsh lands. As far as practicable, we avoid sites at the bases of hills, in ravines, deep valleys, and sites draining higher ground. All low-lying and hollow grounds should be avoided. Into these the water of the higher ground drains and collects, making the site damp and unhealthy. All camps should be as remote as possible from *jheels*, marshes, and swamps. Narrow ravines at the foot of most of our Indian Frontier mountains are malarious, some of them intensely so. No camp should be placed in ravines or the dry beds of water-courses.* A sudden fall of rain or a freshet may convert either into a torrential river. Part of Alexander the Great's army was submerged in the bed of the Indus by a sudden filling of the bed of the river with water. Clay sites are to be avoided on account of their dampness and liability to cause chills, fever, local inflammations, and rheumatism.

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* *Combined Training*, sec. 34.

Damp sites, evils of.—A damp soil is especially to be avoided. The evil effects of constantly living and sleeping on a damp soil soon became manifest amongst all but the hardiest troops. Both the French and the Germans suffered much from this in the autumn of 1870 at Metz. The French troops were bivouacked outside the town, between and outside the forts. They were poorly fed, and suffering from inertia, when in September and October heavy rains made them cheerless and unhealthy to a degree, and their sick-rate rapidly increased; the Germans, with many factors in their favour, including better feeding, had "in some divisions, 50 per cent on the sick list."

Straw for damp sites.—When the use of a damp site is unavoidable, especially in a standing camp, straw should, if possible, be provided. With the regulation allowance of 5 lbs. per man under a waterproof the soldier is rendered comfortably warm, and to a great extent protected against local and general chills. When the quantity of straw is limited, it could be economised by making it into mats 2 or 3 inches thick; these can be exposed to the sun every day to secure dryness. "A straw mat may also be formed by making straw ropes and interlacing them on pickets driven into the ground." *

"The site of the camp should be dry and on grass if possible. Steep slopes must be avoided, but gentle slopes facilitate drainage.

"With undergrowth, low meadows and newly turned soil are apt to be unhealthy. Clay is usually damp. Ravines and water-courses are dangerous sites, as a sudden fall of rain converts them into streams."†

The position of suitable water-supplies largely influences the selection of sites for camps, especially in connection with temporary camps. In more permanent camps it is often desirable to select a site at some distance from the water-supply and bring the water to the camp. "A good water-supply is essential, but considerations of safety may compel the force to camp or bivouac at some distance from it. Facilities of site for shelter, fuel, forage, food, straw, etc., are also taken into consideration."‡

Whenever possible regiments, whether in camp or billeted in villages, should not be far from their water-supply, as this entails greatly increased labour, men losing their rest; and in billets, tends to create confusion.

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* *Manual of Military Engineering*, 1905, p. 78; see also Pl. 65, figs. 2 and 3, and Pl. 67.

† *Combined Training*, 1905, p. 35. ‡ *Ibid*, p. 36.

Most camping grounds require some preparation before pitching the camp—removal of stones, rubbish, long grass, low shrubs, jungle, etc. Jungle and shrubs give shelter to insects and snakes, offer tempting places to throw rubbish in, and hide foul accumulations.

Loose soil sites rapidly contaminated. - It should be remembered that the sites of temporary camps on any kind of loose soil rapidly become contaminated in the absence of the strictest hygienic precautions, and even with the best sanitary cleanliness the site requires to be changed as frequently as practicable.

Sites with rank vegetation, treatment of.—All sites covered with rank or decaying vegetation are unhealthy, chiefly because there is necessarily moisture in the soil, or an excessively humid atmosphere, and when both these conditions are combined, the air is usually laden with the products of vegetable decay. Under these circumstances also there is likely to be swarms of malaria-bearing anopheline mosquitoes. In all stationary camps, whenever jungle and brushwood exist in and around the camp, it ought to be cleared from the camp for a distance of 100 yards. On no account should cut vegetation be allowed to remain in or near the camp—it should be collected into heaps to leeward, and in a day or so will burn readily.

If occupation of a mosquito-ridden area, such as that of a marsh, is, for military reasons, inevitable, it is desirable to encamp to the windward side of it, and, if possible, to have a screen of trees between the camp and the marsh.

Encamping grounds are provided almost throughout the country along the routes frequented by troops, during reliefs, etc. Attached to these is usually a well, with a masonry or brick watering trough for animals, and a *bardasht khana* for supplies.

Whenever there is a choice of sites it is well to select one as if it were to be for more permanent occupation, as a temporary camp may on occasions have to be occupied much longer than anticipated.

" Other points to be considered in the site are facilities for obtaining shelter, fuel, forage and straw." *

Duties of sanitary officers in enemy's country regarding sites.—When marching in brigades or divisions in an unknown enemy's country, a responsible sanitary officer should invariably be with the advanced column; he should have, as far as his branch of work is concerned, and compatible with military exigencies, full authority to ensure his advice and recommendations, sanitary and hygienic, being given effect to.

* *Combined Training*, 1905, p. 35.

Information regarding sites, etc., to be sent back to rest of force.—All information likely to affect or be useful in preserving the health of the troops regarding route, conditions of camping ground, alternative camps, water-supply, quality, quantity and kinds of food-supplies, latrine sites, presence of recent or existing communicable disease amongst inhabitants of adjacent villages or towns, should be transmitted to the advancing units, brigades or divisions. When marching in regiments this information should be provided by the medical officer of the unit and submitted to his commanding officer, who will transmit it to the officer commanding the next advancing unit.

Orders regarding selection of site for camp or bivouac.—When a halt in bivouac has to be made, and where the local population are not to be relied on, a staff officer, with a medical officer and a sufficient number of men may be sent on to choose the site for the bivouac, and to place sentries over the wells on arrival at a village or town. During halts in bivouac the Russians allotted one or two wells for the use of the local inhabitants, and put sentries over the other wells, the sentries taking charge of the ropes and buckets issued on the arrival of the troops. These buckets were used exclusively for the drawing of water. Under these circumstances it is important that the allotment of wells should be definitely fixed for units, etc., as early as practicable. The supply from practically all wells on field service on our Frontiers is comparatively limited, and it is important to ascertain the yield early, as it may be imperative to limit the supply to drinking purposes only.

The principal medical officer is to inspect the towns and villages about to be occupied as to their sanitary condition, and their vicinity; and to formulate a scheme for the organisation of a proper sanitary police to maintain cleanliness and remove nuisances, and for such other purposes affecting the health of the troops as he may deem necessary.

B.—Tents: their Disposition, Capacity and Hygiene.

Regulations regarding general arrangements of camps.—The special points about camps in the field enjoined for consideration by the Regulations are—

(1) the length of time the troops are to occupy the camping ground;

(2) that order, cleanliness, ventilation, and salubrity be ensured;

(3) that means of passing through the camps are essential;

(4) that a straggling camp increases labour and fatigue duties, impedes delivery of supplies and circulation of orders;

(5) that the more compact a camp, the easier is it defended.

Knowledge of Field Service Encampment Regulations required by all officers with the force.—All officers doing duty with troops in the field should make themselves familiar with *Field Encampment Regulations*, India, *Field Service Encampments*, Sec. III, and *Peace Encampment*. The authorised plan of camp should, where practicable, be followed, except when military or strategic reasons call for its modification.

It will be seen from what follows that the health of troops in camp to a large extent depends upon the attention given to the details of its sanitation by all British officers, administrative and executive, with the force, and upon all ranks rigidly obeying and carrying out all orders connected with their sanitary welfare.

It is a good rule to make all arrangements in camps as if they were intended for several days' occupation.

Camps are nothing more than temporary canvas towns in which the actual area covered by the individual tents is densely crowded with occupants.

Tents.—The tents in use in the Indian Army are :—

1. *General Service.*—This is provided with 3 poles and a ridge pole; has a weight of 160 lbs.; length 14 feet, breadth 14 feet, height of walls 1 foot; height of ridge pole 7 feet; cubic space 686 cubic feet. It is used on field service and accommodates 16 British or 20 Native soldiers, or 25 followers. In the case of European troops the cubic space per head is about 43 cubic feet, and in that of Native troops about 34 cubic feet.

2. *General Service* (small).—This has two poles and a ridge pole, weighs 80 lbs, is 8 feet long, 14 feet broad; walls 1 foot high; height to ridge 7 feet; cubic space 392 cubic feet. It is also used on field service and accommodates 8 British, 10 Native soldiers, or 12 followers. This gives 49 cubic feet per head for European troops, and 39 cubic feet for Native soldiers.

3. *Mountain Service.*—This has two poles and a ridge pole; is 12 feet long, 8 broad; wall 10 inches high; height to ridge poles 8 feet; cubic space 544 cubic feet. It is used for field hospitals and accommodates four sick.

4. *British Privates* ("E. P.").—These have two poles and a ridge, and are double-fly tents; they are 20 feet long, 16 broad; walls 5 feet 6 inches high; height to ridge pole 10 feet 6 inches; the cubic space is 2,373 cubic feet; it is sometimes used on field service; accommodating 16 healthy rank and file, or 8 sick men, the cubic space per man being 143 cubic feet in the former case and 286 in the latter. It weighs 400 lbs.

Surface area occupied.—The surface area for general service tents, for different densities of troops, may be tabulated as follows:—

Square yards per tent.	Tents per acre.	POPULATION PER ACRE.		
		British Troops 16 per tent.	Native Troops 20 per tent.	Followers 25 per tent.
(1) 50	96·8	1548·8	1,936	2,420
(2) 100	48·4	774·8	968	1,211
(3) 500	9·68	154·88	193·6	242
(4) 1,000	4·84	77·44	96·8	121

An acre contains 4,840 square yards; one side of a square having an area of one acre is 69·58 yards—roughly 70 yards.

There is no hygienic limit for the space to be occupied in a camp; much depends upon local conditions. The number of troops to be located on a given area has to be determined by local circumstances. The above table gives the extreme limits, ranging from great overcrowding in (1), to what on field service would be usually impracticable, (3) and (4).

Hence the maximum regulation allowance in any of the tents described is 20 square feet and the minimum 11 square feet. This space is also occupied by the men's accoutrements and kit. In peace camps the average is about 17 square feet and on field service about 10 square feet. European soldiers in Indian barracks are allowed 1,440 cubic feet of air-space and 90 feet of superficial space each. On field service therefore he gets only $\frac{1}{30}$ the air-space and less than $\frac{1}{8}$ the superficial space he has in cantonments.

This condensation of men in tents at once shows how easy it is for any communicable disease, once started, to rapidly spread from man to man So serious is this, and so frequently are latent or incipient cases of such disease with a force, that many experienced military medical officers have advocated the bivouac for field service. It is doubtful if this could be done altogether in our Indian Frontier wars either in the hot weather or in winter, although it might with safety be employed in the spring and the late autumn. It may always without much risk be adopted for short periods, in winter. One would certainly advocate bivouacking during our cold weather manœuvres and at all seasons the men should sleep with their tent doors open and

side-walls raised as much as weather permits. "A field force without tents may be uncomfortable but it will be healthy; on the other hand a similar force with tents may be comfortable but it will be less healthy."*

When the tent doors are down it is extremely difficult to ventilate tents properly, whereas barrack-rooms, anyhow in India, are easily ventilated.

We have already dealt with the various questions connected with camp sites and camp sanitation generally, and it is here only necessary to emphasise one or two points already alluded to.

Special points regarding sites.—In the presence of the enemy, tactical considerations, *e.g.*, favourable ground for defence in the event of attack, concealment, facilities for protection and consequently economy in outposts, are of the first importance. The comfort of the troops in conjunction with sanitary conditions is the next consideration.

Sanitary care of unit camps.—The boundary area of each camp must be clearly defined, and the sanitary care for the confines of the camps allotted to commanding officers, *e.g.*, the C. O. of "A" unit to look after the north and east boundary, the C. O. of "B" to look after the south and west, and so on.

Gangway between tents.—A gangway of one yard should be maintained between the pegs of one tent and those of the tents adjoining it.

Intervals between tents.—The usual interval between units is 10 yards. In squadrons of the same regiment, and between the component fractions of an artillery brigade, the interval may be reduced to 1 yard, and between the companies of a battalion of infantry to 3 yards.†

As far as practicable, the Regulations regarding the arrangements of camps are to be adhered to. This, however, has sometimes to be deviated from on account of the physical difficulties connected with the camping ground.

"In brigade and larger encampments one main centre and cross street will run the entire length of the camp. Tents in camp or bivouac should not be cramped for space more than is absolutely necessary. But the dimensions of the camp must not be increased unduly, as a straggling camp entails extra fatigue and delay in circulating orders."

*Colonel R. H. Firth, R.A.M.C., *Military Hygiene*, p. 269.
† *Combined Training*, p. 48.

Tent trenches.—A trench should be dug immediately under the curtain of a tent and the excavated earth banked on its outer edge. The curtain should then be pegged to the inner slope of the trench, the canvas thus draining into it.

Surface drains should be constructed to prevent rain-water lodging in the trenches. Half an hour's work on the first wet day, when the natural run of the water can be seen, will do more to keep the camp dry and healthy than a day's work in dry weather.

Surface drains.—In the case of damp or wet ground, surface drains around tents must be dug even if the camp is to be occupied for one night only. In all standing camps a system of surface drainage should be constructed.

Ventilation of tents.—Tent flies should be looped up the first thing every morning, in wet weather on the leeward side only. In a standing camp, tents should be struck periodically, and the ground well swept and left exposed for some hours at least, the tents being eventually replaced on their former sites. Tents should not be pitched for occupation in the intervals.

Tent doors should generally face away from the prevailing wind, in mounted camps they should face the horse lines. As far as Indian camps are concerned we consider it preferable to permit the wind to strike the air inlets to tents obliquely, and the nearer it does so to an angle of 45° the better. If rain or heavy dew is likely, the tent ropes must be slightly slackened.

Direction of tents.—The direction in which the tents are pitched needs attention. The doors should not, if possible, face due east and west—the long axis of, say, a general service tent, should run north and south—if facing east and west the sun would beat in all day. A certain amount of air-current is necessary—a direct draught through the tents is seldom desirable. It is always better that bleak or cold winds strike the tent at an angle which lets enough air in without danger from chill. When facing north and south, the tent catches the two chief prevailing winds of India, North-West and South-East monsoon winds, at the desired angle.

Ventilation and sunning of tents, kits and beds.—It is very desirable to get the direct sun's rays on the floors of the tent for a few hours daily, and twice a week at least all the kits should be unpacked, spread out in a line parallel with the tents and exposed to the sun; this keeps them dry, aired, and fresh. Bedding and blankets are to be sunned and aired daily by hanging on supports extemporised for the purpose; this is preferable to placing them on the tents as the sun and air get at them thoroughly.

Floors of tents never to be excavated.—It is never permissible from a sanitary point of view to excavate the floor of a tent—it will then often be damp, whilst the exhalations from dug sites may be very pernicious; the level of the men's beds should never be below that of the general surface. It is sometimes desirable to raise the level of the bed in some way. The Regulations of the German Army for standing camps where the soil is not thoroughly clean and firm, is to dig out a few inches, and replace it by gravel, coal-dust, etc., slightly watered, and then covered by boards until dry and hard. Whenever practicable the floors of standing camps should be boarded, the boards being loosely laid and easily removed. Where boards cannot be got, the water-proof sheets must be used, and the soil beaten down to harden it. The surface should once a week or so be scratched for about an inch, and be replaced by gravel.

It is specially necessary in permanent camps to have abundance of room to change the site of the camp, when military exigencies permit of this; and wherever practicable it would be advisable for general officers commanding to allot sufficient ground to allow of this. The site should be changed every four days. When from want of room this is not possible the tents should be struck and the area exposed to the sun and air for several hours, the tents being then repitched.

Foulness of floors in standing camps.—The floor of the tents of standing camps tends to get very foul and charged with organic matter and different kinds of micro-organisms. It is desirable, therefore, to change the positions of all tents at least twice a week. For this purpose the moving of each tent sufficiently to allow the sun to purify the soil of the area that was occupied is all that is required, it does not take more than twenty minutes to move the tents, and it gives the men something to do. Digging up or excavating soil within tents should be forbidden.

Relation between dirt and infectious disease.—The occurrence of dirt in tents and camps generally is always associated with the conditions specially favourable to the spread of infectious or communicable disease. A man suffering from a communicable disease such as tubercle of the lung, enteric fever, etc., is capable of giving rise to the infection to those with whom he is living, if the system in the latter is in a favourable state for the reception of and multiplication of the germ in the body.

Artificial drainage of tents and camps.—Except in countries known to be arid and permanently dry, each tent should be surrounded by a shallow or surface drain, and whenever the camp is occupied for more than one night, a system of surface drains should be made throughout the camp to drain off rain-water, and the possible washings from other polluted areas around. In all these drains the perimeter should be semi-oval, or semi-circular, not rectangular

The direction and depth of the sub-main and main drains will vary with the direction of the fall and the contour level of the ground. The mains should have a depth and width of 12 inches, the sub-mains being somewhat smaller. The mains should run parallel with the camp roadways, and discharge into the perimeter drains; the sub-mains should join the surface drain of the tents and discharge into the mains.

Exposure of interior of tents to sun's rays.—In all standing camps and in all but the most temporary camps, when weather permits, the side-walls or flies should be taken off the ground and secured to the fly ropes to allow of free perflation of air for several hours daily. Whenever men are absent from their tents for a few hours the walls should be looped up and the doors thrown fully open. With general service tents, the whole of one side should be taken bodily over the ridge pole—alternate sides being thus dealt with every second day. This permits the direct sun's rays to get at the interior of the whole tent, and what is in it. Whilst the plan of camps is laid down in Regulations, in standing camps, where space permits, there should always be sufficient room between tents to permit of a free circulation of air. The sanitary officer's ideal in this matter would be to separate each tent from its neighbour by an area equal to at least $1\frac{1}{2}$ times the diameter or breadth of the tent—he considers that within reasonable limits, the farther the lines of tents are apart the better. In civil life, disease and death-rates rise with increase of density of population on area. It is reasonable to expect the same to hold good in camps in the field.

Density of population in camps.—In the area for camps laid down there are over 500 men per acre; in the most densely crowded towns of England there are only 100 persons accommodated to the acre. When a division of troops is encamped in the most "open order," the density of its population on the area occupied is greater than that of any part of London, Liverpool or Glasgow.

It is necessary that all officers should thoroughly understand the risks from infective disease associated with the density of men in tents, and it is incumbent upon all ranks to reduce these risks to a minimum. With every force there is a certain sprinkling of "weaklings," or men suffering from latent infectious disease of some sort, such as malaria, a diseased state of the bowel as in old dysentery, tuberculosis of the lung just beginning, etc.

Dimensions of camp sites.—The frontage of an infantry regimental area is 65 yards by 150 yards or two acres deep, and of an infantry brigade 510 yards by 150 yards deep. A cavalry regiment is allotted $5\frac{1}{2}$ acres and a field battery nearly $2\frac{1}{3}$ acres. These are the minimum areas allotted.

In permanent camps the men should have some form of bedstead—even ordinary charpoys—and when these are not obtainable, there should be a boarded floor. If boards are not available then straw, and tarpaulins or water-proof sheets, are to be used. A comfortable and warm bed may be made by excavating about 4 inches of earth over an area of 6 feet by 2 feet for each man, and filling this area with straw and placing on top of it the water-proof sheet. This should, however, be avoided if possible, as excavating soil from the floor of a tent is usually unhealthy.

If we are to be any length of time in a standing camp we should make the troops as comfortable as possible. It is very advisable to take every precaution, especially in winter, against catching colds and chills. The best way to do this is to provide troops with a sufficient quantity of warm clothes and bedding. With regard to bedding, it should be remembered that it is necessary to have as much beneath as above when sleeping.

Sites of field hospitals, dangers connected with.—The sites of field hospitals, especially in standing camps, may, and often do, become foci for the spread of disease infection. Where such disease is expected, if space and military exigencies permit, field hospitals should be placed as remotely as reasonably practicable from their brigades. These remarks apply particularly to the spread of enteric fever, dysentery and epidemic diarrhœa, although they embrace likewise other diseases. One knows from practical experience that the air and soil in and around field hospitals may become thoroughly impregnated with disease-germs, so much so, that in a few weeks' time half the hospital establishment may be rendered *hors de combat*. When there is any serious amount of communicable disease in camps, such a condition is almost inevitable. The patient worn out with dysentery, or diarrhœa, or on the verge of delirium with typhoid fever, is indifferent as to place when there is an urgent desire to relieve nature. With numbers of such cases in a hospital it becomes a difficult task to prevent contamination of the soil in and around the hospital tents. In a few days, or in a week at most, the soil gets polluted to a high degree. The sick attendants, and the sweepers especially, are few, their duties heavy, supervision is limited, and the unfortunate patient cannot help using the floor of the tent as a latrine. Good hospital discipline and a thoroughly trained staff can do much to postpone the time when saturation of the soil and air with the specific poisons of disease will arrive; unfortunately the more useful the staff, the sooner they knock under from one or other form of disease acquired from actual work in the hospital—this is only the natural consequence of being more or less constantly in and about the sick tents.

On return march old camping grounds to be avoided if possible.—When returning by the route originally traversed we should if

possible avoid the camping grounds previously occupied, particularly those that have been used as standing camps. When this is impossible all sanitary precautions should be rigidly adopted.

There should be a regular inspection of all regimental followers, public and private, cases of infectious or contagious disease if discovered, being at once eliminated.

The ground of the entire camp should be kept clean. Nothing should be allowed to foul the surface. In dusty camps, where water is available, the camp area should be periodically watered. When a camp is to be stationary it is well to harden all the pathways by beating in gravel.

C. —Camp Water-supplies.

The most paramount sanitary duty of commanding officers occupying a camp or bivouac is to secure and place under protection the water-supply. The water-supply will have been chosen by the medical officer of the unit, or the sanitary officer of the division, whose advice as to the way it is to be used and distributed should be rigidly followed. Sentries, or if necessary, patrolling pickets, will be placed over the water and all forms of contamination prevented. Every precaution is to be taken against pollution, surface contamination, and against waste.

A certain number of the men of the sanitary section of the first troops reaching the camping ground should be detailed as sentries over all water-supplies required for the troops to prevent its pollution. They should remain on duty until permanent sentries from the main body can be posted.

In unknown country a sanitary officer should proceed with advanced party to inspect all water-supplies. He will have with him a small cabinet containing chemical reagents with which, if he considers it necessary, he makes a rough and rapid analysis of the different waters; he should then " affix an official lable or notice indicating whether it be sufficiently good to drink untreated, or whether it requires purification before issue, and the forms of purification required." The examination thus carried out is in no sense exhaustive, but the trained sanitary expert, from his knowledge of water-supplies, can usually judge from a simple physical and chemical examination whether the water is dangerous. Such an analysis and opinion would greatly assist medical officers of units who are not provided with such analytical apparatus.

Good and bad wells to be marked.— On field service, wells with water unfit to drink should be marked with a black cross or other distinctive mark. All wells containing water fit to drink, should be indicated by some prearranged mark known to the whole force, such as a thick red cross. Only the best well or wells should bear this mark, and be used by the troops. These marks should be uniformly the same

throughout the force in the campaign. The sanitary medical officer, or medical officer with the leading units, should be responsible that these marks are affixed to wells. If a well (or wells) in the vicinity of the camp contains water of better quality than those in the camp, it should also be marked with a red cross (or other recognised mark) and information to that effect sent to the approaching units. When it is known to the force that wells will be one of the chief sources of supply, it will lessen the labour of drawing water considerably, if buckets and rowels or wheels, with frames to use them, are carried as part of the equipment.

Strict protection of the water-supply imperative.—" If running water is not available, the supply must be very strictly protected, a rough barbed wire fence, if procurable, being run round to keep animals out. Animals should in this case be watered by bucket or nose-bag, and washing should be allowed only at some distance from the water-supply; empty kerosine oil tins, or biscuit tins or other receptacles being used to draw water for this purpose." * We do not approve of this --the one set of buckets should be used for all purposes, and never allowed to leave the well. The biscuit tins or other vessels should be filled from the well buckets. Even when the supply is from a stream, water is preferably drawn for animals. The means for protection of sources of supply are laid down in *F. S P. B.*, p. 41.

Watering of transport animals before reaching camp.—When on the march, it is advisable whenever possible to water all transport animals before they arrive in camp; and, when in camp, they should be watered from a different source to the troops, when the latter get their supply from wells, whenever such a source is available within a reasonable distance. The aggregation of such animals around wells, with drivers and syces, creates a great nuisance and leads to fouling of the water. It is always advisable to water transport and other animals from troughs to prevent their fouling the water of streams, or approaching other sources of supply.

Chief sources of water-supply.—We may here repeat that the chief source of water-supply on field service will usually be rivers, streams, artificial tanks, natural lakes and wells. Amongst the best sources are—large rivers and streams at a distance from towns; large springs, running over a rocky bed, which as a rule can be readily dammed and a reservoir made. Obviously, when more than one source is available, the best will be selected—in the case of wells, this will frequently occur, both as regards quantity and quality. Whatever the source or sources of supply, it must always be guarded by sentries, whose duties will be to prevent any form of pollution of the water. Patrolling

* *Combined Training*, 1905, p. 44.

of rivers or streams by mounted men may sometimes be necessary. Sentries should also be posted over any sources of supply considered unfit for consumption, to prevent men using them. The tired, hot and thirsty soldiers will not always use the best available source, if one of less wholesomeness is a few hundred yards nearer. In this he has got to be watched—it is more necessary to prevent the use of impure or polluted water, than to insist on the use of the more wholesome water

Sources of supplies during modern manœuvres.—During the Rawalpindi Manœuvres of 1905, the troops were supplied with water from local wells, at the Delhi Durbar of 1902-03 by a pipe water-supply extended from the station supply from the Jumna river, and in Agra, chiefly from wells sunk specially for the force.

Investigation of water-supply.—In investigating the water-supply for the force, the chief points to be considered are—its source, quality, quantity, the maximum number of troops it will have to supply at any one time, its history, and local reputation.

Capacity of supply.—With regard to *quantity*, this, except in the case of rivers and fairly large streams, should be ascertained by actual measurement. In the case of small streams, this may present some difficulties which are readily overcome (pp. 84, 85). From wells a limited yield may be the source of great hardship. The supply of wells should always be ascertained—taking the superficial area, depth, and inquiring as to the yield. When the supply is distinctly inadequate for the requirements, the quantity per man must be limited in proportion to the capacity of the supply. Ordinarily a regiment of infantry of field service strength requires roughly about 2,000 gallons of drinking and cooking water *per diem*. When a whole infantry brigade is marching together, it would require roughly 8,000 gallons *per diem*. A rough estimate of water in circular wells is as follows* :—

3 feet in diam.	at top for every	foot of water	...	40 gallons.
4	do.	do.	...	70 ,,
5	do	do	...	120 ,,
6	do	do.	...	170 ,,
7	do.	do.	...	240 ,,
8	do.	do.	...	310 ,,
9	do.	do.	...	390 ,,
10	do.	do.	...	480 ,,

If the supply to a permanent camp is from a stream, a paved pathway should be constructed to the centre of the stream so that water be taken from the main stream and not from the sides, eddies, or back-waters. It is advisable to have separate intakes for European and Native troops when this can be arranged.

* From *Staff College Provisional Memoranda*, 1910, p. 121.

"Where a spring or springs is the source of supply a box or barrel should always be sunk in the spring head to prevent fouling of the water through disturbance during removal. If likely to be used for any length of time, a spring should be enclosed, its level raised, and the ground made to slope away from rather than towards it. If this is impracticable, the vicinity should be so ditched that all surface drainage from upper ground is intercepted and conducted to a point below the level of the spring. The latter may need to be frequently cleaned, and all accumulations of leaves or débris removed."

In marching in India with European troops, in camps where water of reliable quality is not obtainable, the water party should, in the case of infantry, proceed to the next camp the evening before with the necessary utensils to boil the water and have it cool and ready for use by the time the regiment arrives. It is to be stored in large McNamara filters, one of which is required for a battery, and two for a battalion of infantry. The water can be boiled in these tanks. It is necessary to keep the water at the boil for half an hour to completely sterilise it. The water-bottles and mule metal *pakhals* should be filled from this water only. The covered zinc water buckets now used in many barracks should be taken with the battalion and used for distribution of the water—two for a battery and six for a battalion of infantry. Where hand-pumps do not accompany the troops metal buckets with metal chains will be needed to draw water from wells.

The commonest ways in which wells become infected is through the use of vessels and ropes for draining water that have been previously infected—the smallest microscopical amount of infective material from such a source is amply sufficient to start an epidemic amongst those using the well-water.

Protection of well-waters.—All contamination of wells should be rigidly prevented. An area of 30 yards around wells should be kept clean ; no watering of animals, no washing of clothes, and no bathing should be permitted within this area. A space of 20 yards around well or other source of water-supply should be clear of cooking places, animals and tents. No one not actually engaged in drawing water for the men should be allowed within 20 feet of the well. One of the camp police of units should be placed on duty over every well. Surface and subsoil pollution of every kind should be strictly guarded against where it is in any way likely to get at the water. As above remarked a barbed wire fence, if available, about 20 feet from the circumference of the well, is an excellent protective against pollution. Local circumstances may necessitate modification of the foregoing rules.

Where wells are not protected from surface pollution, very special precautions are to be taken. In such cases in temporary camps it

is advisable to build a mud wall around the mouth of the well a foot or eighteen inches high, and prevent all unauthorised persons approaching the well.

Whenever it is practicable the water-supply for the troops from wells should be closed to the civil population for the time being.

Distribution of water in camps.—In general water has to be distributed in camps by means of water-carts, wheeled tanks, metal *pakhals*, barrels, pails, canvas bags, earthenware chatties, kerosine oil tins, etc. Each and all of these should be thoroughly cleaned regularly. The best way of doing this is to wash these water containers out with water rendered a deep purple with permanganate of potassium repeatedly until water in them remains of a pink colour. All water containers must be kept covered, and wherever possible access to the water should only be by taps. Men should never drink directly from taps or other containers of stored water.

It is desirable not to bring more water into camps than the regulation allowance, for an excess usually means waste All water brought into camp has to reach the surface and be drained away, and if not so drained, a very insanitary condition soon arises.

F. S. P. B. lays down that the daily average per man for drinking and cooking purposes is 1 gallon. In standing camps the least allowance that should be given per man for all purposes is 5 gallons a day, and for a horse 10 gallons.

Search after water.—In many cases in which the possibility of obtaining a water-supply source has been entirely relinquished, water may still be found if the natural sources of water are more carefully investigated. Few precise rules can be laid down in searching for water. On a plain, the depth at which water will be found will depend on the permeability of the soil, and the depth at which hard rock or clay will hold up water. The plain should be well surveyed, and, if any part seems below the general level, a well should be sunk, or trials made with Norton's tube-wells. The part most covered with herbage is likely to have the water nearest the surface. On a dry sandy plain, morning mists or swarms of insects sometimes mark water below. Surface springs should be sought for in hollows, at the foot of hills where the earth is moist or where the grass is unusually green, and where the thickest mists rise in the mornings or evenings.

Subterranean streams.—Among the hills the search for water is easier. The hills store up water, which runs off into plains at their feet. Wells should be sunk at the foot of hills, not on a spur, and if possible at the lowest point; and if there are any indications of a water-course, as near that course as possible. In the valleys among hills the junction of two long valleys will, especially if there is any narrowing,

generally give water. The outlet of the longest valley should be chosen, and if there is any trace of the junction of two water-courses, the well should be sunk at their union. In a long valley with a contraction, water should be sought for on the mountain side of the contraction. In digging at the side of a valley, the side with the highest hill should be chosen before commencing to dig, the country should be as carefully looked over as time and opportunity permit, and the dip of the strata made out if possible. A little search will sometimes show which is the direction of fall from high grounds or a watershed. If moist ground only is reached, the insertion of a tube, pierced with holes, deep in the moist ground, will sometimes cause a good deal of water to be collected. Norton's American tube-well gave satisfaction in Abyssinia, although it was not satisfactory in Ashantee.

Where no form of water-supply is visible, it may be necessary to sink wells and make reservoirs. It is well known that the valleys or beds of rivers in India and on its Frontiers have often a subterranean stream, that may, as a rule, be readily tapped by our field engineers when no other source of water-supply is at hand.

It may be necessary to sink Norton's ("Abyssinian") tubes, and

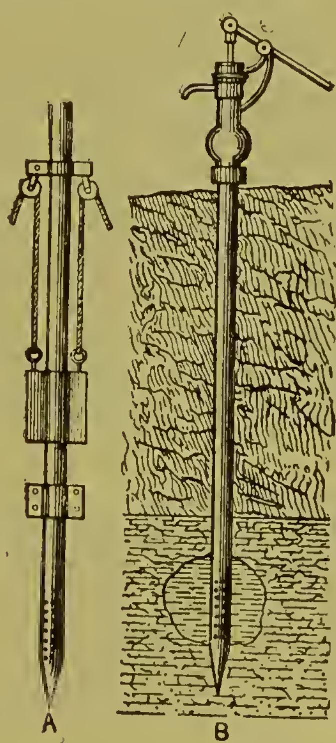

FIG. 37.—Norton's tubes: A.—Apparatus for driving; B.—Driven well.

when wells or other sources of supply are likely to fail, sites for the use of these tubes should be sought early.

The question of the purification of water on field service has already been dealt with *in extenso* (pp. 114—134). The disadvantages of boiling are chiefly connected with the expense of fuel, the carrying of the fuel, the water is rendered flat and insipid, and having been boiled, it has to cool before being usable. The expense and transport of fuel are the real difficulties. Water-boiling stations should, when practicable, be established on the lines of communication, at every halting place, and, where necessary, at railway stations, and troops passing through should fill their water-bottles with boiled water.

Cleanliness of water-bottles.—Special attention should be given to the cleanliness of men's water-bottles. This is an important duty. It is useless to put sterilised water into germ-laden, unclean bottles. Water-bottles should be scalded and rinsed out twice a week. This need only take a few minutes; it should be done at a definite fixed time, and water for the purpose provided, both on field service and on manœuvres or on the march, the refuse water being discharged into an absorption pit. In the absence of boiling water the water-bottle might be washed in a solution of permanganate of potassium if this is available. Very hot tea kept in the water-bottle for an hour or so is also a partial steriliser. Tea that has first been infused, put into water-bottles, and allowed to cool, is quite safe. Cold tea sterilises a water-bottle as far as typhoid bacilli are concerned in 24 hours. In the absence of any of these means, the water-bottle may be rinsed out three or four times with clean cold water under supervision and as a matter of routine duty. Water-bottles should not be scoured out with sand and pebbles, as these themselves often contain disease-germs which may directly infect the bottle. Water should not be kept in water-bottles when they are not in use. "The Italian pattern bottle requires periodical soaking to prevent its becoming too dry (*K. R.*, 1908, § 1717). It is advisable for men to cultivate the habit of boiling unsafe water in their own mess tins, as it may happen on field service that this is the only way it can be sterilised; this was done by the Japanese during part of their Manchurian campaign.

Water discipline should be insisted on with all recruits. Properly disciplined men with empty water-bottles will not, under ordinary circumstances, drink the nearest water available until they know that it is wholesome (see p. 80). Most of us drink an excess of fluid in one form or another, much of which we would be the better without.

D.—Food and Kitchens.

Essential points regarding field dietry.—Too much attention cannot be given to the food of the soldier in the field, especially as to the quality and quantity of its staple articles and to its variety; a liberal allowance of vegetables, particularly fresh potatoes and onions,

should be provided, as well as fresh meat to European troops and some branches of the Native Army ; and the food should invariably be properly cooked. The culinary processes in temporary camps and on the march are usually rough and ready. This subject is fully dealt with in the section on FOOD.

Sites for kitchens, etc.—When large bodies of troops are concentrated, the G. O. C. of the force or division will decide the general position of latrines and kitchens of each area, that is, whether they are to be front, rear, or flank of an area.

In regard to kitchens special attention should be directed to the following points :—They should be well away from latrines and urinals and all accumulations of camp refuse. All sullage water should be, passed into pits from which it can drain away along suitably directed trenches.

Definite rules should be prescribed and hung up regarding the washing-up of all cooking and feeding utensils, and cleanliness of the kitchen and its surroundings.

The washing-up arrangements in kitchens require careful supervision. A special place should be fixed for this in connection with the company or double company kitchens of both European and Native troops. It should have a sufficient quantity of boiled or filtered water. Bath-brick powder is required for scouring cooking utensils of European troops, and for Native troops either ashes or baked sand; the ordinary earth is on no account to be used fresh from the ground, as its use for this purpose is the cause of several diseases in cantonments, and may be a serious cause of these and other diseases on field service, as such earth always swarms with germs. The whole of the washing-up process should be supervised by one of the specially trained men of the sanitary squad in British regiments, and the sanitary police in Native regiments.

All food in camps should be invariably kept in covered utensils or receptacles. Doolies or meat-safes cannot, of course, be carried for European troops, but it is possible to carry a folding or collapsible metal framework with suspending metal beams and hooks, covered with some close-meshed cotton material, such as strong mosquito-netting, the food being placed within this portable dooly.

All milk should be thoroughly boiled and protected from dust and flies, preferably in metal cans or corked bottles, or be at least covered with some form of muslin.

Garbage and kitchen refuse should never be thrown on the ground. There should be special allotted plots, receptacles, or baskets for it. In temporary camps small pits are best, the contents being daily covered with 6 inches of earth and flies prevented from access.

In standing camps all dry kitchen refuse should be either burnt in the kitchen fire, or covered with petroleum and removed to the camp incinerator regularly after each meal has been served.

Kitchen slops contain much grease, which, on the surface of the soil, forms a putrescible and offensive scum that is very attractive to flies. The pits may be filled with coarse brushwood on which the grease, etc., is caught up; the brushwood which is loaded with fat should be burnt daily and replaced by fresh stuff.

Absorption pits may be made in practically all camps—they consist of excavations filled with stones below and gravel above, and covered with brushwood, dried grass, straw, *bhoosa*, etc, which is burnt and replaced daily. These can be readily improvised from materials always at hand.

The following methods of disposal of kitchen slop-water have been found to work well. They were devised by Captain TILBURY BROWN, R.A.M.C. :—

"Take two large biscuit tins, the upper acting as a coarse strainer and the lower serving to direct the water over and into a small pit, which,

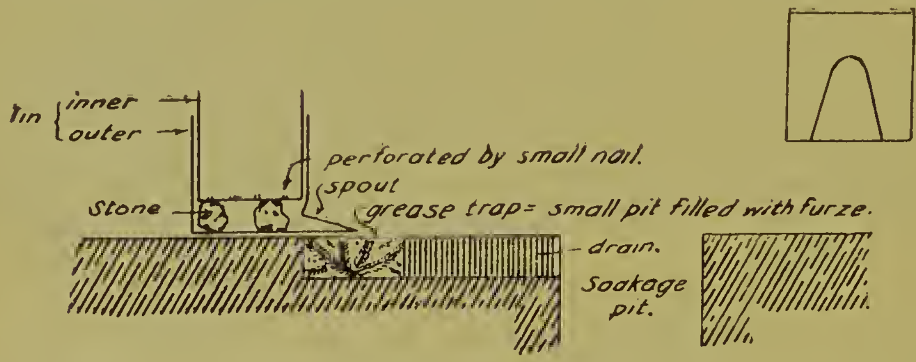

FIG 38.—Improvised grease-trap

filled with grass or brushwood, acts as a grease trap. From this small pit cut a shallow trench leading to a large soakage pit. The inner tin should rest on two or more stones, so as to allow an interspace. The spout from the lower tin is conveniently made by cutting an inverted V-shaped flap from one of the sides turning it down and rounding off. Modifications of the foregoing can be made by turning a box upside down over the pit or grease-trap, the bottom of the

box being perforated with a hole into which is fitted a calender or perforated tin.

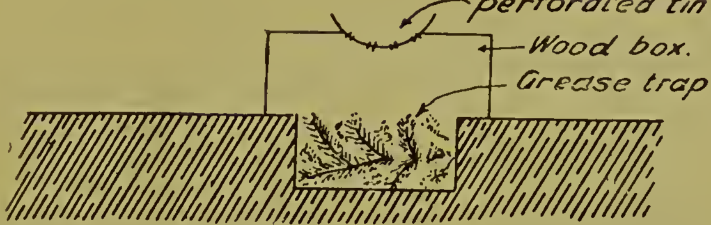

FIG 39.—Improvised grease-trap.

"A more elaborate improvised grease-trap can be made to discharge into either a special soakage pit or any convenient ditch. In all

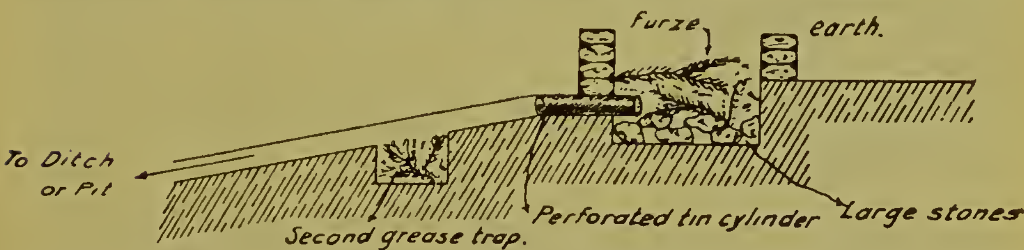

FIG. 40.—Improvised grease-trap.

cases the grass or brushwood used is burnt and removed daily." The brushwood should be soaked in crude petroleum, which prevents the approach of flies and assists in its subsequent incineration. Another simple method which may be adopted in temporary camps is the following:—

"Two pits 2 feet square and 2 feet deep, and with the bottom earth loosened 6 inches more, should be dug 20 yards away from each company or double company cook-house. One of these is to be used for water and the other for garbage and other dry kitchen refuse. Dry earth is to be thrown in each several times a day, and on leaving camp a layer of litter 4 inches deep should be burnt on each, and the pit then well covered with earth."

In permanent camps where the soil does not permit of drainage or soakage, it is necessary to move the position of the kitchen and ablution places at least twice a week, or what is preferable in such a case, to arrange for the daily removal of all sullage water in water-tight receptacles with proper covers. These should be on raised platforms. The contents should be discharged into allotted places outside the camp daily.

Food should not be eaten in tents; nor should it be stored or retained in tents. If such storage cannot be avoided, it should be reduced to a minimum and always placed in closed tins or boxes and

be inaccessible to flies. Exposed food rapidly deteriorates and gets infected by flies. All scraps of food left over from meals should be burnt or buried. No refuse food should be thrown around the tents; where some form of temporary receptacle, such as kerosine oil or biscuit tins or boxes, cannot be provided, all such refuse must be accumulated in one or two definite places adjacent to company tents, to be removed twice daily or oftener. All kinds of washing, such as that of mess tins, feet, socks, etc., must be conducted in specially allotted places. Urinating outside tents in unauthorised places should be made a disciplinary matter.

The coffee-shops should have their dry refuse receptacle, washing-up place, absorption pit and grease-trap, as in the case of the men's kitchens.

All markets opened in the field for the sale of fresh provisions should be subjected to strict supervision, and only such food as is passed by a medical officer as fit for consumption should be permitted to be sold. The regimental sanitary police should insist on all orders on this point being rigidly adhered to. This refers to both European and Native troops.

It is a sound rule to prevent all hawkers or vendors of foods and unauthorised natives generally coming into or in the immediate vicinity of the camp. Apart from the possibility of disease being created by the foods sold, such persons sometimes bring infectious disease into camps.

Milk-supply on field service.—The milk-supply in the field is always a source of danger in one way or another, and, as procured on our Frontiers, is usually poor in quality. Town and village *gowallahs* can seldom be induced to bring their cows or goats to the camp to be milked; the earthen, wooden or metal vessels it is brought in are nearly always very dirty. It is often ready to "turn" and on boiling frequently curdles. Whenever such milk is available, it must be carefully watched and must always be boiled before use. It will seldom be that dairy supplies are available. This absence of reliable milk deprives the British soldier of an article of diet to which he is daily accustomed in peace times. There are some brands of condensed milk in tins now procurable which are cheap, reliable, and form an excellent substitute for fresh milk. These might be kept in canteens or coffee-shops, and several men share one tin when using it with tea or coffee.

All villages and towns *en route* to and near camping grounds should be placed out of bounds.

E.—Latrine Trenches.

The trench system has, up to the present time, invariably been used on field service in Indian Frontier warfare. This is the dry-

earth system of cantonments without removal, the excreta being deposited directly into an elongated excavation in the ground, instead of into a pan.

As soon as the camp site has been chosen sites for latrines and urinals have to be selected. These should be constructed at once. This is to be insisted on if the halt is to last for only a few hours, and the sanitary police and sweepers employed in the same way as if the camp were to be occupied for days. The sites for latrines must be carefully chosen.

Trenches to be ready for troops on their arrival in camp.—"Whenever it is possible arrangements should be made to have the latrines duly ready for use on the arrival of the men in camp. This latter provision obviates the necessity of resorting to fields or jungle or confines of the camp for purposes of nature." During such halts temporary trenches should always be dug and filled up before quitting.

When for any reason an advance party cannot be sent ahead to prepare the camp, a halt should be made about a mile or less from the proposed side to permit the men and animals to relieve nature.

Position of trenches.—In standing camps, if the distance fixed is 100 yards from the camp, the first trench should be excavated 120 yards away. When about half full it should be completely filled with the excavated earth which has been heaped up on the far side of the trench from the camp. No earth should be banked on the near side, as this prevents comfortable access to the edge of the pit. The next trench is excavated a yard nearer the camp, and so on. This method prevents the men having to pass over used trenches. All ordure scattered around or near the trenches should be regularly shovelled into the pit by the sweepers on duty.

Latrines, urinals, refuse pits, cattle lines, etc., must be situated at least 100 yards from, and when practicable, to leeward of the nearest tents, water-supply, bakery, slaughtering-place, and kitchens. They must never be placed in or near gullies, ravines, *nullahs* or hollows which, when it rains, discharge into the water-supply, nor in any situation the drainage or filtration from which may possibly reach and so pollute the water-supply.* In such situations a single heavy shower may suddenly wash the excreta into streams, etc. When rain threatens this has to be guarded against.

Night-soil trenches, their dimensions and management.—For temporary camps the usual night-soil trench is a pit 50 feet long, 2 feet deep, and 16 inches wide, for every 400 men. This permits of 25 men using the trench at the same time. With such trenches the front edge gets fouled with urine (and often with fæces) and sloppy. In

* *Combined Training*, 1905, p. 47.

temporary camps the remedy for this evil is to dig a succession of short trenches in parallel across which the user straddles, and thus readily directs both solid and liquid dejecta clean into the pit. Each such trench is to be 3 feet long, 2 feet deep, and 1 foot wide, and the space

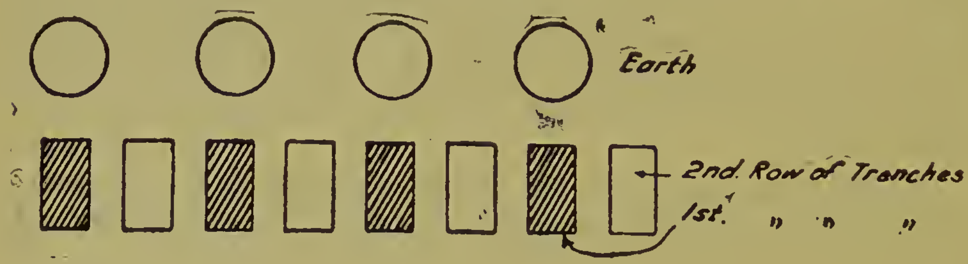

FIG. 41.—Diagram of short-trench latrine.

between each trench 3 feet or less. The excavated earth is to be broken up and placed behind the trenches. Such trenches are altogether easier to manage, dig, and keep clean. A seat at right angles supported on a forked upright may be used. These trenches usually last one day and they must be filled up and fresh ones dug daily. The old ones are to be carefully and solidly filled up. For permanent camps and where area is limited the old long trench is better as it does not infect such a large surface of ground. It is sometimes, from the nature and limitations of the available ground, more convenient to dig trenches 50 feet long, 16 inches wide at the top, and 2 feet deep. Two such trenches are sufficient for an infantry battalion. All the latrine trenches of each unit should be together. With Native regiments it is desirable to dig in addition one trench of 9 feet long, or three of 3 feet in length, but of the same width and depth, for Native officers. A similar trench should be excavated for followers. It is a good plan to have the trenches a trifle wider below than on top to avoid soiling the sides, which is a very general nuisance on field service, especially when men squat too far from the edge. This often leads to the users tramping on actual ordure, especially at night, and conveying the material ou their boots to the tents. The excrement so carried may contain the germs of enteric fever, dysentery, or other disease.

All trenches should be provided with some sort of shovel, spade, scoop, empty tins, tin lids, etc., for covering the night-soil with earth each time the trench is used. The boots should not be used for pushing earth in. Flies will find their way to any exposed fresh human excreta. The user of the trench, or sweeper in attendance should cover deposited excreta with dry earth.

For temporary camps there should be a sweeper provided with a shovel or spade on duty, his special duty being to cover all exposed excreta. One sweeper should be on duty so long as the trench is being

used, certainly from dawn or Reveille to Last Post. Dry earth should be thrown into the latrine pits several times a day, in addition to the covering of each man's excreta with earth.

The trenches should be filled in when the contents are within a foot of the surface. The sites of the filled trenches should be so marked that they can be at once recognised by those occupying the camp subsequently, and so as to obviate the possibility of tents being pitched over them. Paper should be prevented from blowing about. The paper used by European troops may be fixed to the screen by a string. The proper disposal of the dry earth after using the trench prevents used paper being blown about.

A sentry should be placed in charge of the latrines to see that each person covers his excreta with earth, or that the sweeper on duty does so. When necessary a proper pathway should be made to the latrines and this should be carried out at once. This is a frequent requirement in hill warfare that is often neglected. Every latrine should be screened off, even in temporary camps.

The sites of the latrine trenches for European and Native troops should be marked by distinctive flags.

In camps used for one day only the earth removed from the trenches originally is to be piled up for a foot over the trenches to mark their site, extra earth from the surrounding area being used for this purpose if necessary.

In open trenches it is probable that the use of disinfectants is of but limited value in destroying disease germs. Disinfectant powders are certainly useless, although they may deodorise. Chloride of lime or quicklime mixed with water when obtainable is most useful for keeping away flies.

Men should be warned to defæcate directly into the pit. Marginal excrement gets on the boots, is carried about and into tents, dries, pulverises, and is wafted over the whole camp. European troops should that the paper used reaches the bottom of the pit, otherwise it is blown about. The sweeper in attendance at the trench should every hour add an inch or so of fresh earth and completely cover exposed excrement. Native troops are in the habit of quitting the site after defæcation, and washing themselves in the vicinity. This should be strictly forbidden. The men must perform these ablutions so that the soiled water falls into the trenches.

Deodorisation of trenches.—"The contents of the latrine trenches should be covered with earth as often as possible, and at least twice

daily, milk of lime (1 part quicklime to 8 parts of water) should be freely used in latrines, urine pits (or receptacles), refuse pits, or slaughtering-places, and on the ground around them."*

Bamboo seats for trenches.—In standing camps for European troops a long bamboo running the length of the trench and supported at the ends by stakes is advisable. These enable the men to use the latrines in comfort. In standing camps the trenches may conveniently be provided with seats, these latter consisting of a bamboo or wooden pole supported by stakes. Additional comfort while using the latrine may be given by adding a top pole to form a back.†

Prescribed trench accommodation.—For bivouacs latrine accommodation for 3 per cent. is required, for temporary camps 5 per cent., and for camps of more than a few days 8 per cent. This means that a yard of linear trench space is required for 3, 5, and 8 men per hundred respectively. "Latrines should be constructed to seat about 5 per cent. of the strength of units, allowing one yard per man. The trenches should be narrow and deep, to prevent the contents being blown about. A few inches of earth should be thrown over the night-soil twice daily. This properly carried out prevents the development of flies. Lime may be used for the same purpose and it also acts as a deodoriser."‡ From experience one is disposed to consider that the percentage allowed is rather high and that where area is limited an accommodation for 3 per cent. suffices.

In rainy weather a shallow drain should be made around the latrine pit to prevent the inflow of rain-water into the trenches.

It is desirable for obvious reasons that some form of light latrine screens be provided. A brushwood screen can often be made from the jungle surrounding camps. The side walls of European privates tents are admirable, but coarse canvas, or gunny-bag cloth held in position by light bamboos, answers the purpose.

Committing a nuisance in or near camps to be punished.—The indiscriminate use of the ground near and around camps for purposes of nature should be absolutely forbidden. This rule must be rigidly enforced, and the larger the force, the more urgent the necessity of punishing offenders.

Night latrine trenches.—In an enemy's country, especially when "sniping" or a night attack is expected, latrines must be close to the perimeter, and covered by the range of view of the perimeter sentries. The sites of these must be carefully chosen to leeward, and, except when camping for one night, some form of movable receptacle

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* *Combined Training*, 1905, p. 47.

† *Manual of Military Engineering*, 1905, p. 69; see also Pl. 61, Figs. 1 and 2; other forms are shown in Figs. 6 and 7 of the same Plate.

‡ *Ibid*, p. 69.

(kerosine oil tins, packing cases), etc., with burial at a distance, should be used if possible, and in their absence trenches of the same size as the urinals (see below) should be dug and used as the larger day trenches are. These, however, require the closest possible supervision, and may, if neglected, become a serious source of disease in the force. They should be discontinued as early as practicable, and never used in a friendly country, or where the day latrine may be used without risk. When dried stable litter or dry rubbish is available, it may be successfully employed to mitigate the evils inseparable from these close night trenches. "The litter is spread 4 or 5 inches thick at the bottom of a wide and shallow trench, so that the excrement will be deposited on the top of the litter, the litter early every morning is set fire to, and the whole reduced to ashes and then covered. Where space is available, a new night latrine should be dug every day."

Filling up of night-soil trenches.—All latrine trenches must be filled up and properly covered with earth before the camp is quitted. As a routine practice, the position of the previous night-soil pits should be indicated by some mark—dry lime powder sprinkled over the surface answers well; this may, of course, be obliterated by rain.

In permanent camps it is desirable to have some form of roof to latrines, and the nearer the system approaches that of incineration or removal as carried out in cantonments, the better. It usually consists of some form of pail system with dry earth, and the latrine of some form of rough wooden seats screened off. The day urinals will be near the latrines. The contents of the pails will be removed by carts or other receptacles and buried deeply remote from the camps.

If the pail system is not practicable, then the pits should be dug deep and the excreta be regularly covered with earth. This requires rigid supervision, attention to detail, and strict obedience of all orders on the part of the men.

It is possible to use kerosine oil tins as receptacles for excreta in permanent camps. When used some form of liquid disinfectant is advisable, the excreta being subsequently disposed of by deep burial. One has tried this on a small scale and can speak of it as a means of keeping off flies, although it is clumsy and somewhat laborious.

Incineration in the field.—Whenever practicable night-soil incinerators should be improvised in permanent camps. Numerous forms of incinerators have been suggested and described for the destruction of excreta and dry refuse on field service, and all engineers and sanitary officers with an expedition are able to improvise one or other pattern from materials obtainable in the field. The following suggestions

for field incineration are the result of practical experience, and are set forth as a guide to those who have not yet carried out this system elsewhere than in cantonments.

"It must be borne in mind that all machinery requires attention to detail for its correct working in practice. It is not reasonable to expect that sanitary orderlies and their establishment will be able to incinerate in the field by the light of nature. They must all have been trained before leaving cantonments. Consequently as the field incinerator is equally efficacious in cantonments, each unit should erect one at least for instructional purposes.

The requirements are—a trained sanitary cadre, latrine pans, iron bars for incinerators, fuel and transport.

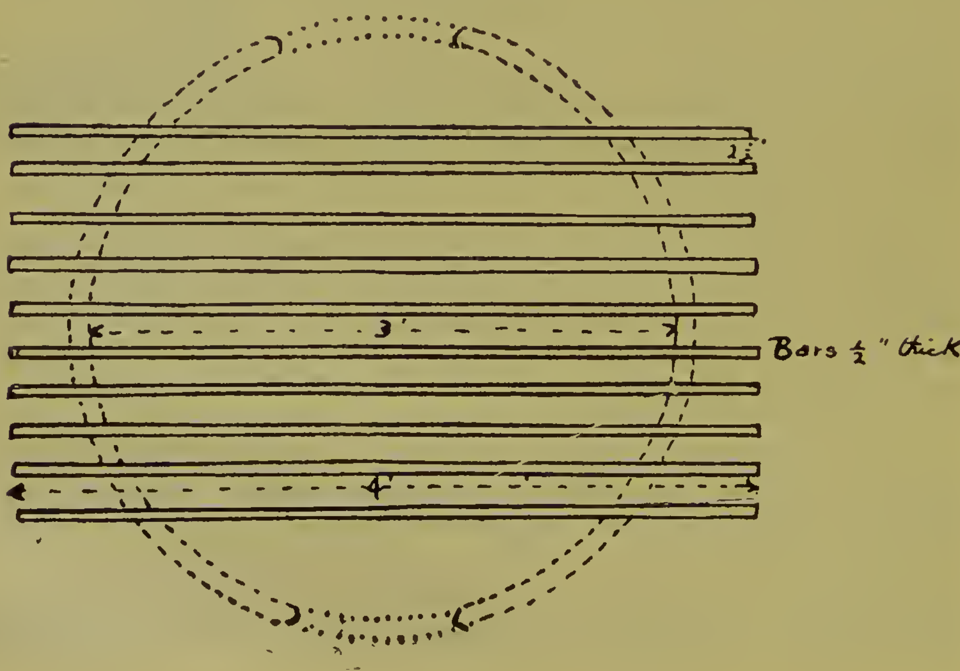
1. The sanitary cadre for British troops is laid down in India Army Order 354 of 1907.

Of these trained orderlies a proportion is told off to deal with camp cleanliness, and under them are the sweepers. Indian units should conform to these lines.

2. Latrine pans can sometimes be obtained on loan from Cantonment Magistrates, or they can be provided at small cost in the proportion of 5 per cent. of the strength of the unit. They are made of iron, and are shallow oval-shaped pans or buckets about twice as long as broad. Persons using them can squat over them. They can be lowered into the soil if considered too high.

3. Light iron bars, say about ½ inch in diameter, 4 feet in length, in

A.—Plan.



B.—Elevation.

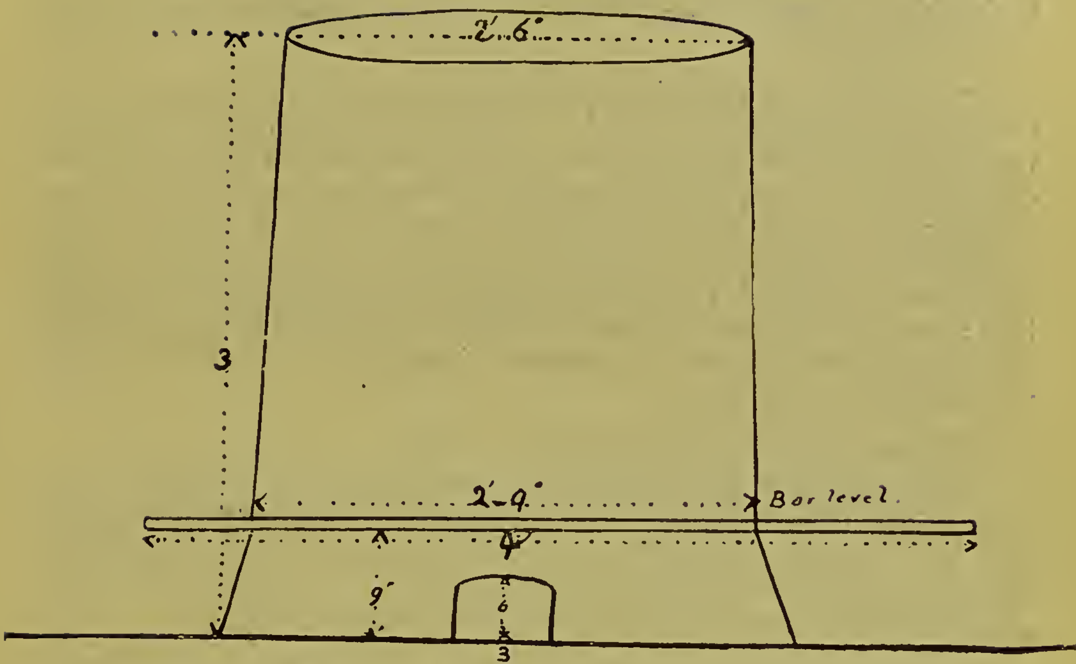


Fig. 42.—Plan (A) and Elevation (B) of night-soil incinerator for camps or cantonments.

sets of 10, are required for the construction of incinerators. An infantry battalion at full strength would find it convenient to have three sets of these bars, other units require two. Serviceable incinerators can be extemporised out of the bands used to secure bales of hay.

4. *Fuel.*—Mounted troops and transport have no difficulty in this respect. Infantry, when operating independently, may require a special supply to commence with on arrival in camp. This may be obtained as a special supply of a bale of bedding grass. When brigaded, the litter of camps should be distributed among units under Brigade Orders.

5. The question of transport must be arranged for locally. The weight of material to be carried for all infantry battalions in about 160 lbs. Although this is only one mule load, it may be necessary to arrange for two mules per unit, in order to provide for detached parties.

"An incinerator should be built beside each group of latrines. This is done by preparing thick mud, from which brick-like pieces should be formed. These should then be arranged round a circle 3 feet in diameter, inside measurement. At first four equidistant spaces are left to form draught holes. When this segmented wall is 6 inches high, the draught holes are bridged over by making the wall continuous. When the wall is about 8 or 9 inches high, the bars are laid across the opening, leaving an equal interval between each bar, projecting towards one

point of the compass. The height of the well should be about 3 feet; it should have a slight slope inward, so that the upper opening should be 2½ feet across.

"If the soil is too sandy for this turves and roots of herbage with soil adherent should be utilised. It may be impossible in such cases to raise the wells as high as 3 feet. It will be necessary then to rest content with such an erection as will raise the bars 8 or 9 inches above the ground, and will afford at least a low containing wall above the bars sufficient to prevent wind blowing refuse about. In such soil it may sometimes be found convenient to make a cross-cut trench, to lay the bars across the intersection, and to build a small containing wall. But this practice should not be adopted if avoidable, as it is difficult to remove ash from the trench.

The routine to be followed is:—

Upon arrival in camp, the latrine site having been indicated, the pans (with litter in them) are laid out ready for use, and the sweepers and *bhisti* at once proceed to make mud and then to build an incinerator. Under ordinary circumstances with trained personnel, this takes about an hour. Fuel is collected from the lines and vicinity.

Incineration is then proceeded with. Six inches depth litter is laid upon the bars and ignited. As soon as this is burning, more litter is placed upon the fire, and when this has a good hold, the contents of the pans are tipped over into the fire, each pan being cleaned out with litter which is at once burnt.

Urinals (empty tins) are preferably not to be tipped over, but the soaked litter in them is to be placed in the incinerator; more litter should then be added to the urine until the whole has been soaked up. When urine has to be emptied directly into the fire only small quantities should be poured in at one time and the furnace given time to recover between each emptying. In peace movements, when the quartermaster's party precede the main body, one set of bars and half the pans are carried to the next camp and the latrine arrangements prepared. The bars and pans in the old camp are brought on as soon as the camp has been duly cleared up.

The above procedure was successfully carried out last winter by a cavalry brigade as well as by other units, British and Indian, and the result of their experience is noted for general information, with the reminder that no process can be efficiently executed without due training of the workmen."

Units which do not carry out efficient sanitation are a danger to the force. Medical officers of units must be held responsible that insanitary practices are at once reported to the commanding officers who are responsible for the sanitation of their areas (*K. R.*, §100, amended by A. O. 137 of 30th March 1908).

"It is essential that special attention should be paid by the transport corps to incineration, and a strict discipline be maintained over all followers to prevent their reverting to primitive methods."

Where incinerators are in use shortly after Reveille they should be thoroughly cleared of ashes and made fit to commence the day's work.

Normal healthy excreta is innocuous.—Normal healthy excreta, as a rule, except when in a high state of putrefaction and the products of decomposition concentrated, do not give rise to disease, but on field service we have practically always men with latent infective disease or recovering from communicable disease, with the force, who are a danger to others. With healthy excreta, flies from privies, whilst they annoy, do not give rise to infectious disease, even if they reach our food, etc.

Pail system for standing camps.—"Care should be taken to prevent the pollution by latrines or refuse pits of ground within 100 yards of the encampment, or any possible extension of it. An improvised pail system of latrines should be established if possible.

This would necessitate the use of carts and buckets, pails, or receptacles, or one of the latter with removal by the conservancy sweepers, or what is far preferable, the erection of incinerators.

The buckets must be emptied into carts, and both carts and buckets must be cleaned every day. The carts should have water-tight covers, be provided with tipping lids, and a derrick that will enable the buckets to be emptied with a minimum of handling and without the possibility of contents being splashed about or spilt.

When a system of pail latrines is in operation, they should be suitably placed in relation to the camp. Buckets are best, but kerosine oil tins serve the purpose. They should be in proper position in relation to the seat. With the pail system, solutions of liquid disinfectants, such as saponified cresol (1 to 640) are decidedly of use in preventing the multiplication of disease germs.

Dangers of enteric fever from fæces and urine.—The risk of enteric fever from human fæces and urine, and of dysentery and epidemic diarrhœa from fæces, should be made a matter of general knowledge throughout the army.

Breeding of flies in night-soil trenches—its dangers.—The breeding of flies in latrine trenches should, as far as practicable, be prevented. For this purpose the best precaution is the use of crude petroleum, which when sprinkled over an open trench is most valuable in keeping flies away from its contents. It is the cheapest of all agents that can be used for this purpose. On a small scale one has used kerosine oil in hospital latrines for several years, and can speak of its value as an enemy to flies. Lime, when liberally used in trenches, may also help to prevent flies breeding. The free use of such disinfectants as cresol (1 to 640) does the same.

"Flies and other insects carry disease, and all food should be protected from them. This can be prevented to some extent by keeping all sites, especially horse lines, scrupulously clean. All refuse and litter should be burnt, buried or removed far from the troops."*

In Manchuria the Japanese found that flies laid their eggs chiefly in horse-dung and refuse generally, the burning of which to some extent mitigated the nuisance and prevented mature flies from developing in swarms. Quicklime, ashes of every description, and thoroughly dried earth were sprinkled upon night-soil, so that flies could not have direct contact with it.

F.—Urinaries.

Day urinaries.—For temporary camps the day urinal may consist of excavations in the soil, circular or square trenches within the latrine screen and to windward of the latrine trenches. Where the earth is absorbent it soon disappears, but it should be covered with earth twice a day. The most common soil along our Frontiers and in camping grounds in Northern India is alluvium, consisting of a mixture of clay, loam, and saud, and this is sufficiently absorbent to remove all urine. When the soil does not soak up all the urine, fresh urine pits should be dug as ofteu as necessary, aud the pits should be 3 feet deep. In all cases earth should be thrown into the trenches several times a day. Lime, when available, is a useful agent for urine trenches to keep down odour and prevent access of flies.

Night urinaries.—It is very desirable that some form of receptacle be provided as *urinaries* for night use to prevent soiling of the ground around tents, and the possible spread of enteric fever by this means. Empty kerosine oil tins, obtainable for this purpose without much difficulty or expense, form part of the regular equipment. Old biscuit tins, buckets or pails of some description may all answer this purpose. They should be partly filled with grass, straw or *bhoosa*. They should be removed at Reveille, and emptied into the day urine trenches or preferably into special pits. Where such receptacles are uot obtainable and the ground is porous (gravelly or sandy), small trenches 2 feet deep by 3 feet long and 1 foot wide might be excavated to oue or other flank of the unit, four such per battalion. When half full they should be filled up with dry earth, closed, and fresh ones dug for use. Sufficient earth to absorb the urine of the previous night should be added to these trenches every morniug. In all cases the pits should be closed for use at Reveille, aud when they cousist of mere excavations in the earth, filled up. They are not to be used during the day. Men found urinating iu unauthorised places should be punished.

There are many ways of making urine pits for night use, and medical officers can always devise some plan that will prevent them being either a nuisance or injurious to health. Those pits will best

* *Combined Training*, 1905, p. 47.

take the form of shallow trenches leading to a pit filled with large stones, the trench being for urinating into, the pit to take the excess which does not soak into the trench. Roughly, two trenches each six feet long will suffice for 600 men. The gradient should be a fall of 1 inch to a foot, and the width some 9 inches to a foot. The catch pit will vary in depth and size according to soil and number of men using the trenches; one 3 feet deep and 2 feet in diameter in moderately porous soil should suffice for 600 men. If the pits fill rapidly then either fresh pits are to be dug, or the old pit partly refilled with loose earth. Each of these urine drains in good porous soil lasts for a few days, while the pit will in such soil act efficiently and without offensiveness for ten days. When foul, new ones must be dug and the old ones filled in. A typical example of this rough urinal is shown in Fig. 43; the trenches can be dug as radii from the pit, or as the hands

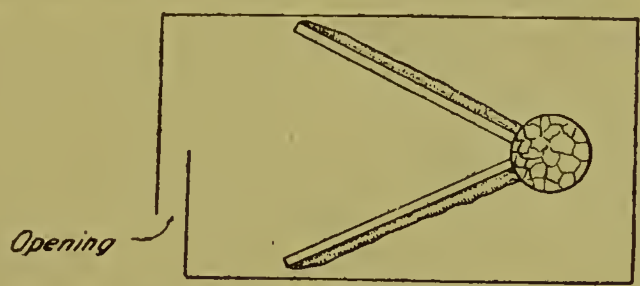


FIG. 43.—Plan of camp urinal.

of a watch. In some cases it may be feasible to screen off the pit, to prevent men actually micturating into it, shifting the screen with

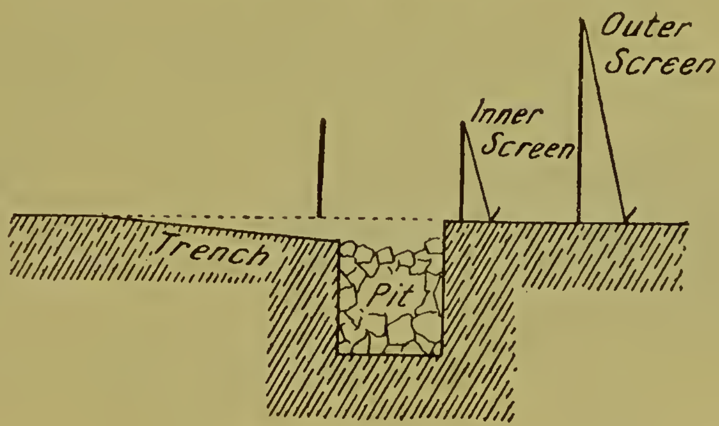


FIG. 44.—Diagram of camp urinal.

the trenches, or, better still, cover the pit with sods, leaving apertures by which the contributing trenches may drain into it Often the urine will not soak away rapidly; if so, one must either dig fresh pits or partly refill the pit with loose earth, when usually it will be found that the urine quickly gets absorbed.

Night urinals should be on the flanks of the camps, not between the tents. Their positions should be marked by white-washed posts.

Portable sewage sterilisers.—Various forms of portable apparatus have been advocated for the sterilisation of excreta under the conditions of military life in peace and on service. One of these was described in the *Journal of the Royal Army Medical Corps* for November 1905 by Lieutenant-Colonel GLENN ALLEN, R.A.M.C. In it the sterilisation (of pathogenic or disease-producing bacteria) is effected by raising the temperature of the sewage to 140° F., and he considers that a temperature of even 131° F. for 5 minutes would suffice. Such apparatus have been used by the U. S. Army at different times. They are cumbersome, exceedingly unportable, and, as they are quite impracticable in Indian Frontier warfare, will not be further alluded to here.

G.—DRY REFUSE OF CAMPS AND ITS DISPOSAL.

Dry refuse and its disposal in camps.—As soon as the site of the camp is fixed a place should be selected for the final deposit and accumulation of all refuse. This should be at a distance (not less than 120 yards from the nearest point of the camp and further, if possible), situated to leeward and away from the water-supply and kitchens. The distance away will naturally vary with the size of camp, facility for conveying the refuse, and other circumstances. All refuse is to be removed as expeditiously as possible from the vicinity of tents, huts, billets or bivouacs. It is very necessary that all solid refuse of camps be kept dry. It is sometimes useful to collect all refuse of the camp, except that of the kitchens, in gunny bags, several times a day, carry it to leeward of the camp and burn it. In standing camps pits 4 feet square and 4 feet deep may be excavated, dry refuse thrown into them and burnt daily, the incineration being assisted if necessary with crude mineral oil. The matter of the final disposal of all camp refuse should be in the hands of the Divisional Sanitary Officer, and he should have full authority to devise and insist on his orders being carried out. Refuse should never be thrown into ravines and gullies or depressions on the surface. All accumulated rubbish in the presence of heat and moisture must necessarily ferment, become a nuisance, and a possible source of disease and flies.

Final disposal of rubbish.—It may be disposed of by burial or incineration. Burial may be used where only a small force has to be provided for and the outskirts of camps are easily reached. With a large force some form of incinerator is indispensable.

If carts are used for removal of dry refuse, as will usually be the case on the lines of communication and in permanent camps, they should be such as will not permit the refuse falling out.

Methods of incinerating refuse.—Incineration may be carried out in various ways—from the burning of refuse on the ground at the site selected, to its cremation in specially constructed incinera-

tors. During the Cuban campaign around Santiago, the camp refuse was incorporated with more combustible materials such as crude petroleum before ignition. A successful plan was to deposit the rubbish on a raised platform of iron rails under which a brisk fire was kept going. This means expense from the quantity of mineral oil and fuel used. In several of our Indian campaigns the rubbish has been consumed in improvised incinerators like lime-kilns as was done in the Crimea, and in dry weather when they can be placed over 200 yards to leeward of camps, this is one of the simplest methods of dealing with it, in wet weather or when the combustion is incomplete and slow, it may become a disgusting nuisance. In several Frontier expeditions our field engineers have constructed refuse incinerators with a low chimney from kutcha bricks or even mud. The special point one would insist on is that in standing camps all refuse must be burnt one way or another. Incineration in such camps is the one way of dealing with rubbish and garbage of all sorts—kitchen refuse, camp sweepings, litter from standings of all transport animals, offal of all kinds, straw, paper, rags, bones, empty tins, broken bottles, etc.—should be burnt and the incombustible residue buried. In connection with latrine trenches we have alluded to the terrible nuisance possible from the breeding of flies in the trenches—and the same remarks, though to a less extent, apply to moist and fermenting camp refuse. All moist and incombustible animal, vegetable, and other refuse which cannot be burnt, must be carried away to a suitable place to leeward of the camp, and buried.

An excellent form of refuse incinerator was devised at Harrismith by Conductor Tomkins and Major Clark which has the following advantages :—

(1) Simplicity and cheapness.
(2) Rapidity of action—especially in wet weather.
(3) Manure may be loaded directly into it.

"The apparatus may be described as a large trough made of

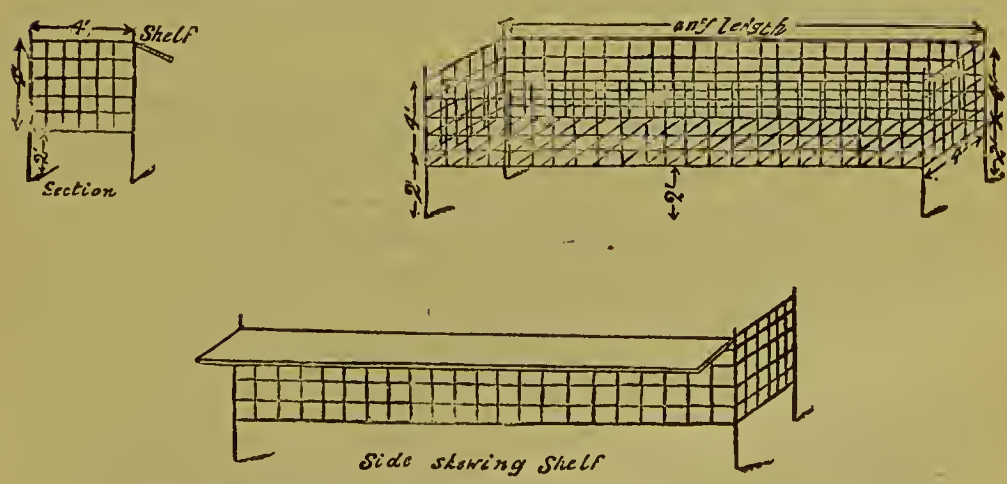


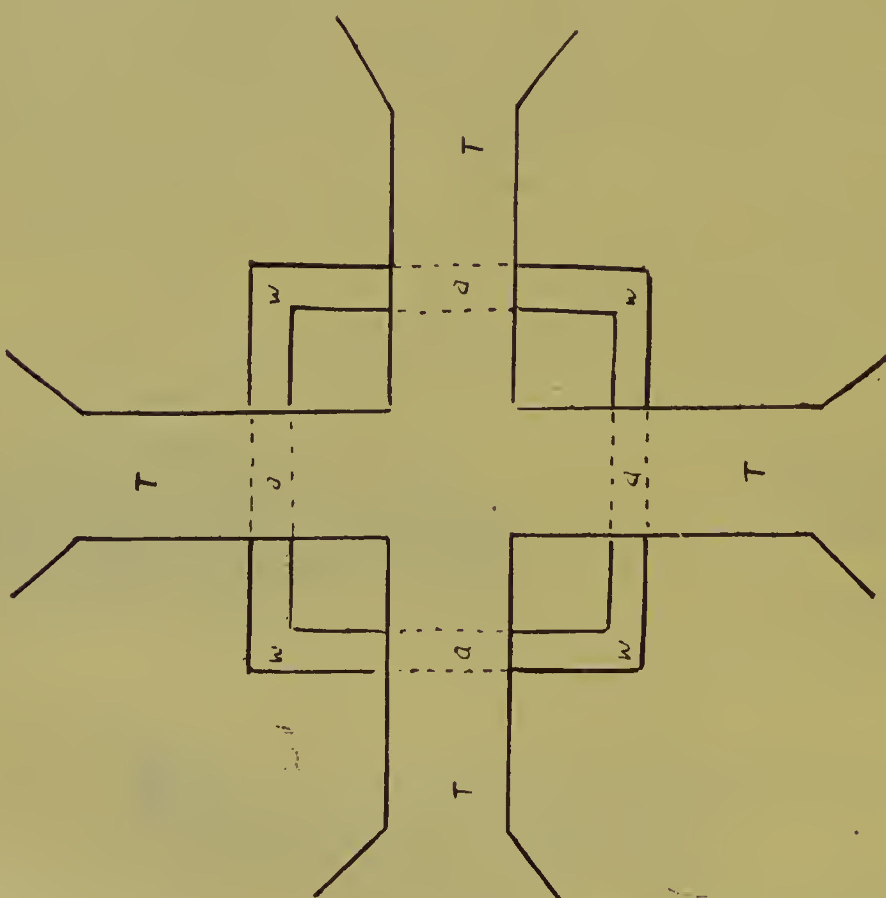
FIG. 45.—Improvised dry refuse incinerator.

wire-work, raised two feet above the ground. The trough may be of any length, but should be 4 feet wide and deep. It should be broadside on to the prevailing wind, and the bars forming the bottom of it ought to run from side to side and not lengthwise. The mesh must be about 5 inches square, and a 'shelf' of corrugated iron or other material about a foot wide should be fastened along the top to reduce spillage while the litter is being transferred from cart to destructor. The waggon to be unloaded is backed right up to the incinerator; and the litter is set alight in the ordinary way, near the bottom."

Lieutenant-Colonel E. A. MORRIS, R.A.M.C., has described a simple and easily constructed refuse destructor for camps and cantonments. "The site having been selected two trenches are dug crossing each other at right angles, each trench being four feet long and ten inches wide, sloping down from each end to a depth of nine inches in the centre, the ends being further splayed outwards to increase the draught.

"At the intersections of the trenches a square is now laid 2 feet

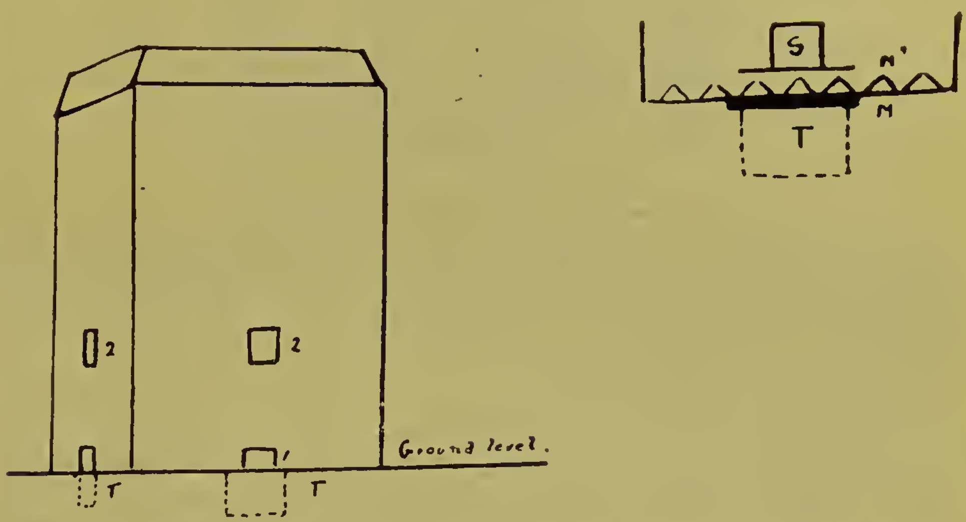
A



A.—Ground Plan of destructor: A, arches; T, trenches; W, walls.

8 inches in outside measurement and 20 inches inside (W. W. Fig.46, A) thus giving a space of 6 inches wide for walls ; the intervals at each trench are bridged over with a piece of Merwara flag of suitable width

B



B.—End view of grating, N : M. Merwara flags; T, trench ; S, stoke-hole.
Fig. 46.—Plan and elevation of refuse destructor for cantonments and camps.

On the foundations thus formed seven pieces of angle iron 2 feet 6 inches long are laid down at regular intervals to form a grating, the angle being placed upwards; another piece of flag is placed over the ends of the three central bars to hold them in position at the stoke-holes (*m* Fig. 46, B), and the building of the walls is then proceeded with. The walls may be either of sun-dried bricks set in mud or of old bricks set in mud or mortar. A hole 4 inches square is left over the centre of each trench to allow of ashes being raked down, and the grating cleared occasionally, another hole being left in each side wall 1 foot higher up to increase draught.

"Just before the rains the walls were plastered over with a mixture of cow-dung and clay, the whole was then given a good coating of tar. The seven pieces of iron cost Rs. 3. The sweepers can build the wall.

"The reduction in cartage by this simple destructor is very great; formerly in the hospital three cart-loads of rubbish were taken away daily, now one cartload of ash is accumulated every three days If these destructors were generally adopted fully half the authorised establishment of rubbish carts might be dispensed with."*

An excellent modification of the above which one has used on several occasions in camps is a rectangular or cylindrical chamber built of either mud or sods provided with air-inlets at the base. This is one

* *Journal of the Royal Army Medical Corps.* September 1908, pp. 305, 306.

of the simplest and easiest form of refuse destructor to work for small

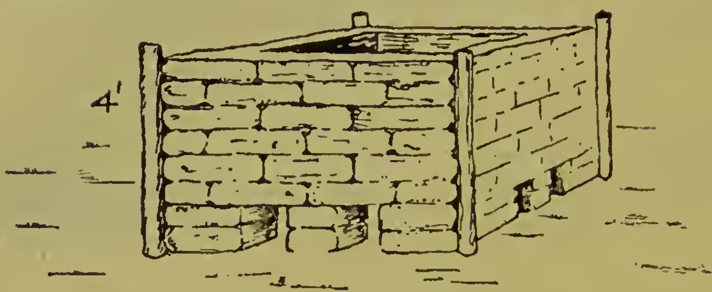


Fig. 47.—Improvised camp refuse crematory.

amounts of rubbish. The feeding with refuse should not be too rapid or it will smother the fire, and the air-inlets should be repeatedly raked and kept open and free for air to enter quickly, especially if the refuse is at all wet.

"An improvised refuse destructor of a simple nature can be made by digging two trenches intersecting each other at right angles; each trench should be 9 inches deep and any length for 5 feet. Over the angles of intersection a chimney or shaft is built up of sods of earth, a few bars of iron hooping or other resistant material supporting the chimney where its walls cross the trenches. A fire can be quickly lighted at the base of the chimney and fed steadily by throwing rubbish and refuse down

Fig. 48.—Plan of improvised camp refuse crematory.
(From *Journal of the Royal Army Medical Corps.*)

the top. Assuming the refuse to be added with ordinary care and the patency of the draught trenches maintained by judicious raking, an enormous amount of combustible refuse can be disposed of in a few hours. Such an arrangement needs supervision and care." *

Another effective refuse crematory is one consisting of a circular pit 3 feet deep and 15 feet in diameter (Fig. 49); the bottom is covered with loose stones to the depth of a foot, and on this a circumferential wall is built up to the height of a foot above the ground level, the excavated earth being packed against it to prevent surface-water

* Colonel R. H. Firth, R.A.M.C., *Military Hygiene*, pp. 278, 279.

gaining access to the pit, and also to provide a sloping approach for tilting refuse into it. A pyramid of large stones occupies the

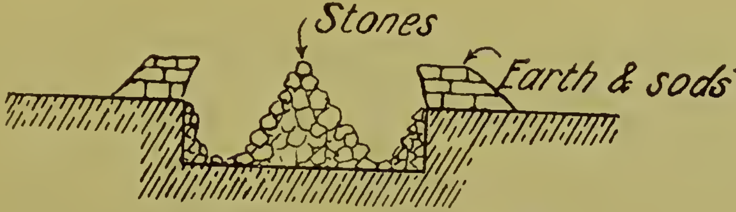


FIG. 49.—Camp refuse crematory.

centre to a height of 5 feet; this is essential to provide a steady draught through the centre of the burning material. Ordinary wood must be used to start the fire, and after it is well burning it can be steadily maintained by adding refuse and garbage. The stones soon become intensely hot, and serve to dispose of liquid and damp stuff with great rapidity. This is an ingenious and most effective camp crematory, as we have demonstrated, but it is not of universal applicability; good large stones are a necessity, and they are not to be found in sufficient numbers in all places. Where they can be obtained we can testify to the efficiency of this device.*

The construction of a simple grate by laying railway rails so as to form a grid or platform on lateral supports may be entirely successful in maintaining a brisk fire, fed with camp refuse.

Another rough way is to form a framework of kerosine oil tins or other tins with air-spaces between, throwing the rubbish on the tins and regulating it below. This acts in the same way as the burning of bricks with refuse does in brick-kilns on the clamp pattern.

In any method of this kind adopted the great point is to ensure a free draught of air under and through the refuse to provide the necessary oxygen for combustion; the wetter the refuse, the more air naturally is required to burn it.

In temporary camps with small quantities of refuse it is only necessary to make the refuse into a heap mixed with as much dry grass and dry sticks as can be got and set it on fire.

Method of dealing with refuse regimentally.—The simplest way is for each battalion to deal with its own refuse, burning it daily. In dry weather this is easily achieved by excavating for each battalion a shallow pit a few inches deep, spreading out the rubbish on it to dry, and then burning it *in situ*. Under a good drying sun, it soon becomes highly combustible. Where, from deficiency of space or the arrangement of surrounding camps, this cannot be done, the refuse of a whole

* Colonel R. H. FIRTH, R.A.M.C., *Military Hygiene*, pp. 280, 281.

brigade may be deposited in the one place. With an adequate conservancy establishment, and especially if rubbish carts are in use, this is a preferable way, as from the mass of refuse its combustion is better insured.

Where incinerators cannot be constructed the best rule is to burn all refuse that is inflammable and bury the rest, but such burial should always be away from the water-supply and kitchens.

The final sweeping of the camping ground should not be commenced until the unit has marched off. If in an enemy's country and the sweepers must accompany the main body, then the camp area should first be sprinkled with water and swept, the main body in the meantime getting ready to march.

Various portable incinerators have been proposed and in some cases used for camps and on field service. Of these Horsfall's is said to be very satisfactory for fixed encampments, but for moving camps its weight and difficulty of transport are disadvantages. The same objections hold good with the different movable refuse incinerators hitherto used, so that as far as our Indian Frontier wars are concerned they are as impracticable as they are unnecessary. Frequently individual ingenuity will be able to devise better methods than any of these movable incinerators. This remark does not apply to the several forms of portable metal night soil incinerators which have during the last few years been experimented with during manœuvres; these have in many instances worked admirably, and as they consume the dry refuse of camps, to a large extent solve the difficulty of disposal of dry refuse and night-soil.

From what has been said it will be evident that in all standing camps, wherever practicable, incinerators should be constructed for burning camp refuse, dead animals, etc.

Unattached transport animals.—A vast number of transport animals are constantly passing to and from the front with provisions, who pollute the camping grounds. Most rigid rules should be published that the drivers must accumulate their animals' litter in one place, and all neglect in this respect should be severely punished. In dry weather with a bright sun, such litter will soon be sufficiently combustible, but in moist weather it becomes a source of much insanitation. As these convoys usually leave early in the morning, it is difficult to catch the delinquents, and practically whatever steps are taken there is always a nuisance that must be faced and remedied. The provost-marshal's duties are at such times onerous. Followers of this class, forming the movable population of camps, are also the most frequent delinquents in committing nuisance in and around camps. All hired transport requires special watching.

Transport and horse lines.—Horse lines and those of transport animals require careful attention as to their sanitation. The dung of

animals must be removed daily as otherwise it dries and is blown about, or forms a place specially favoured by flies, the latter soon diffusing through the whole camp.

Complete cleanliness of all transport lines should be rigidly enforced. The standings of all animals of transport corps require careful supervision, and the drivers compelled to collect and remove all litter to the allotted places daily and if possible incinerate it. All drivers neglecting this duty should be punished. The standings of the animals should also be changed twice a week, to allow the previous standing to be thoroughly cleaned, and the sun to purify the ground, and re-fit it for use if necessary. A neglected transport camp may become a horrible nuisance—it has happened that the entire position of the camp of the force has been abandoned on this account, as at Khar during the Chitral Relief Expedition in 1894. All transport animals where practicable should be picketed near and parallel to the main roads (but away from all source of water-supply), to avoid soiling the camp.

When the space available for the camp is limited, there is necessarily over-crowding of men and transport animals—if the arrangements for maintaining the camp really clean are restricted to a minimum, we have all the conditions present to create rapidly spreading disease of various kinds. Such was the condition of Karuppa at the time of its evacuation in December 1897.

Sweepers' brooms and gunny bags or baskets for regiments.—Quarter-masters of regiments should take with them a sufficient supply of serviceable brooms and gunny bags or baskets for the company sweepers. With these in hand, the sweepers will have no excuse for neglecting their work. Gunny-bags, sacks, baskets, or some substitute for them, are very necessary to remove the kitchen and camp refuse generally, to the place allotted for it.

An adequate extra conservancy establishment necessary.—Whilst under ordinary circumstances the sanitary cleaning of camps, collection and disposal of refuse, and work of the night-soil pits, is carried out by the company sweepers of units, in actual practice on field service it is found that these are inadequate, and would be altogether so, when the task of eradication of infectious disease arose. An adequate extra conservancy establishment should accompany the force and be placed at the disposal of provost-marshals or camp staff officers. They should be equally distributed in divisions. A few in excess for each battalion is sound economy. They could be utilised also to replace casualties from sickness or other causes amongst sweepers. With a deficient conservancy establishment it becomes necessary to use the sweepers of units and this can only be done at the expense of the sanitary state of camps of the separate corps, which is a very undesirable contingency.

Filling up of ditches, pits, etc.—All ditches, pools, and pits near tents should as far as practicable be filled up with earth. On our Indian Frontier pits are frequently created by people removing the earth for building purposes. When they excavate the ground to a certain level, the subsoil water flows into the pit. This is the origin of a large number of the superficial wells in many villages and towns. The water from such wells is very impure. These pits, if not formed into wells, are used for committing nuisances in, or for throwing rubbish into, which rubbish after rain mixes with the rain-water and makes the place very unhealthy. All such excavations should be filled up with earth. If this is not practicable, their mouth should be closed by a substantial cover, or the circumference surrounded by a protecting barrier. We have more than once known accidents to arise from persons falling into such excavations.

H.—Ablution Places.

In all standing camps the troops should have facilities for bathing, and if hot water can be provided for the purpose so much the better. Water can be readily heated in boilers where there is sufficient fuel; if necessary such fuel might be obtained through regimental arrangements.

Except along rivers and streams it is difficult to make satisfactory arrangements for the bathing of men and washing of clothes on the march to and from the front, or actually in the field. It is usually possible to improvise some form of trough for this purpose. When the men can be provided with wash-hand basins or buckets, there should be no difficulty in keeping themselves clean.

It is always desirable to provide some form of privacy for the bathing places. In permanent camps where European privates tents or marquees are available, the interior may be divided off into bathing compartments by canvas screens. Even with general service tents this is easy to arrange for in most standing camps. The compartment

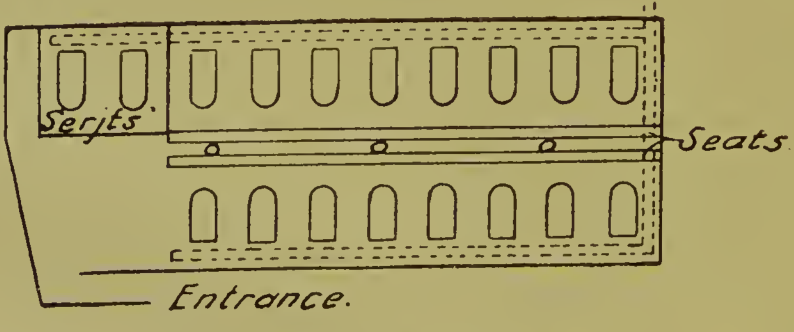


Fig. 50.—Improvised bathing place.

should have a seat, and a metal or canvas bath. The bath-water should be discharged over waste ground along specially made drains. The

method of disposal of kitchen slops is applicable to that of ablution water unless the soil is very impervious.

With regard to the Native Army there is always the risk of creating an unhealthy swamp on the confines of bathing and washing places, when these are not connected with rivers or streams. To obviate this it is desirable to allot a place for bathing, away from the well, tank, etc., supplying drinking water, and another for washing clothes. A sanitary policeman should be on duty at the principal washing and bathing times to see that the men cause all the water to flow into the drains (which should be made) and pits, and prevent water being thrown about the surface.

I.—Washing and Drying of Clothes.

Some form of clothes washing bench is a useful addition for washing articles of soiled clothing, such as socks, shirts, drawers, etc., which can be easily dried; and this washing of clothes by the men should be encouraged.

The clothing of the Japanese soldier was washed as often as opportunities occurred, and they had with them disinfecting apparatus with which the clothing, etc., belonging to each soldier was disinfected or sterilised whenever it was thought necessary to do so. Each of these disinfecting apparatus had a capacity for disinfecting the clothes of 20 men at a time. "There were more than 100 of these disinfectors in use, and they were a very useful means of preventing any epidemic disease from spreading" (Surgeon-General Takaki.)

In all camps there should be arrangements for men drying their clothes. The construction of simple devices for this purpose gives some scope for ingenuity. Any kind of framework will do—iron hooping, telegraph wire, bamboos, etc., with ordinary *chulas* below the framework. This may be carried out in special tents or temporary sheds constructed for the purpose, or (in dry weather) in the open.

J.—Disposal of Dead Animals.

As soon as an animal dies, arrangements should be made for its immediate removal from the camp. This removal should always be effected before decay of the carcase commences. Sanitary policemen should, on their rounds, be on the look-out for dead dogs, cats, rats, etc., and have them immediately conveyed from the neighbourhood of camps. If the animal dies from an infectious or contagious disease, it should be covered with a layer of lime, and at once carted or carried out of the camp limits and burnt or buried deep in the soil away from all water sources. Dead animals of any description should not be thrown into dust-bins or refuse heaps or mixed with the dry refuse. The Japanese in Manchuria either buried or burnt all dead animals according to circumstances.

In the absence of big refuse incinerators the burning of carcases of large animals (camels, oxen, mules, etc.,) is quite impracticable. Burial is equally so where a large number of animals have to be dealt with. The only alternative is to drag the animals several hundred yards to leeward of the camp, remove and bury the viscera, and let natural processes of decay do the rest—various carnivorous birds and animals help in this process. The degree of offensiveness in the decay may be lessened by charring the interior where there is some combustible material at hand to effect this. When an animal dies of some infectious disease it is better not to remove the entrails. The place to which dead animals are to be dragged and how they are to be disposed of should be included in the sanitary orders of camps. For the disinfection of *carcases of animals* dead of bacterial disease destruction by fire is the best, but it is seldom it can be carried out. They are usually buried in a deep pit of sufficient size, the carcases being thrown on to quicklime, which agent should also be thrown over and all round them. The abdominal and thoracic cavities should first be opened so that the lime can reach these regions. Where large refuse or night-soil incinerators are in use the carcases should be quartered and burnt.

K.—Slaughtering-place, Etc.

The sites of the shambles should be fixed and orders given as to how all offal is to be disposed of—this will usually be by burial or incineration. Slaughtering should be carried out at least 100 yards away from the camp and from latrines ; all offal should be buried in pits at least 3 feet deep in one-day camps, and 4 feet deep in standing camps, and as fresh offal is added earth should be thrown in, and finally refuse burnt over it and an earth covering laid as in the case of latrine trenches.

Site for cemetery.—In standing camps, specially with a large force, some well-chosen place away from the water-supply and reasonably remote from the force should be fixed as a cemetery. The burial should always be in deep graves, and where infective disease has been the cause of death, every possible precaution should be taken against spreading the disease by infection along the route to the cemetery and from the cemetery itself. Over the bodies of their dead the Japanese spread a layer of lime, charcoal, ashes, or slack.

Notice boards.—It is desirable to put up notice boards directing to the position of the source of water-supply, latrines, urinals, refuse pits, hospitals, bazaar (if there is one), and a plan showing the location of these should be on view at the camp commandant's office.

New arrivals.—All new arrivals at the front must be made thoroughly familiar with every sanitary and preventive measure adopted in the force.

L.— Huts, Billets, Shelter Tents, and Bivouacs.

Huts for all but temporary occupation desirable.—Whenever the occupation is of a permanent nature, as in investments and the defences of strategical positions, it is desirable to hut the troops. They keep better health in them. The employment of huts has greatly extended in modern times in armies, both in peace and on field service. In war they are a means of rapidly housing an army, and are always better for winter quarters than tents. "Before erecting huts the ground should be cleaned and levelled, and a trench dug round the site of the hut sufficiently deep to drain it. Huts should neither have the earth dug up from inside, nor heaped against the outside; they should stand detached, at a sufficient distance from each other, and from the neighbouring higher ground, to allow of a free circulation of air around them. In warm climates the floor should be sufficiently raised above the ground to allow a free circulation of air beneath."

Essentials in construction of huts.—The hut should be provided with ridge ventilation and projecting eaves to carry off the rain-water from the foundations; it should have the requisite number of windows, and should be raised sufficiently above the ground to allow of a free current of air to pass beneath the flooring. In hot climates the roof and sides should be double, if these latter are not protected from the sun by verandahs. They are best arranged *en echelon* to get full advantage of wind for ventilation purposes. Warming may be effected by the use of stoves or an open grate, the latter also assisting ventilation. When huts are for permanent occupation it is preferable to make the walls of first class brick. Lord Wolseley advises that temporary huts on service should be constructed to hold 28 men and should have the following dimensions:—32 feet long, 16 broad, 6 feet to eaves, 16 feet to ridge, giving a cubic space of 400 feet per man. Two such huts may be placed end to end with a chimney between them. The roof may be made of felt or tarred calico, secured by strips of wood. If the rainfall is heavy, the roof should be made steep to throw off the rain. If the flooring is made of wood, it should be fastened by screws and not nails—to allow of removal of boards for cleaning; if of earth a few inches should be removed from time to time and replaced by gravel, and the latter should be beaten down. Earth is most objectionable as a flooring; it soon becomes contaminated, and it may be impregnated with disease-germs; every movement or gust of wind raises small clouds of dust with any contained germs. Ashes from wooden fires, well rammed down, make a good floor.

It is preferable to have a movable roof to huts, and one of the best is a water-proof sheeting of some kind, or tarpaulin, which could take the place of different kinds of material recommended in the *Manual of Military Engineering*, 1905. The enormous advantage gained by a movable roof is that it permits of the interior of the hut being thoroughly exposed to the sun and air whenever necessary. In really

tropical weather such a roof cannot, of course, be used for European troops. When properly constructed wooden huts may be made quite cool.

When huts are in use the doors and windows should be kept open whenever weather permits, and always for several hours each day. If the roof is of canvas it should be rolled or turned back for a few hours daily or at least twice a week.

Huts have become popular buildings in India, especially on the hills. They are healthy and the outlay in their construction is comparatively small. They are better adapted for a cold winter than tents.

Materials for making huts.—The materials used in the making of huts are determined by what is locally available, and usually consists of brushwood, logs, reeds, straw, clay, and turf. The best form of hut is rectangular in plan with sufficient width for two rows of beds and a passage down the centre, but when the material available is of small size, one row of beds may be provided, or the hut may be made of circular form. A width of at least 6 feet should be allowed for each row of beds, and the passage may be from 2 feet to 4 feet. The accommodation may be calculated on active service at one man per foot in length of the hut, when there are two rows of beds, and one man to every 2 feet when only one row of beds.

Hurdle shelters.—Hurdles may be of special dimensions for hutting purposes, thus, a hurdle 10 feet long (measured on the curve) may be made into a hut. The hurdle is constructed on a curve slightly flatter than that it is intended to have, so that it is necessary to spring it together to get it into position. It is then secured with pickets and covered with sods or daubed with clay. The ground forming the floor of the hut may be sloped before putting on the hurdles. Hurdles for hutting should have the ends of the picket cut off as close to the web as possible, so as to leave no gaps between them.

When brushwood of 2 inches or 3 inches diameter and 14 feet or 15 feet long is available, a hut may be constructed for a double row of beds. The section of a hut being decided on, is laid out on the ground; from this the length of the rafters is obtained. Each side of the roof is then made separately on the ground as follows:—Poles 2″ to 3″ diameter are laid on the ground parallel to each other, from 18″ to 24″ apart. These form the rafters. On the slope of the rafters and at right angles to them, light rods or laths from $\frac{1}{2}$ to $\frac{3}{4}$ inch are laid, the top-most one being at such a distance from the bottom of the poles as will allow the frames, when made, to lock at the desired height above the ground, the lowermost one being within a few inches of the bottom, and the interval between being divided according to the length of the thatching or covering material. The distance apart of these laths should be slightly less than half the length of the covering material, so that the latter may be supported at three points. With good wheaten straw the interval may be from 12″ to 18″. At each point of crossing the laths and rafters are secured by a short length of one strand of spun yarn, and the frame thus made is afterwards stiffened by diagonals lashed underneath.

The *roofing material*, which may be of unbroken straw, long ferns, etc., is now put on. Commencing at the bottom a layer 4 or 5 inches thick is equally laid over the three lowest laths, ears or tops downwards; it is here secured by a light rod or thatching piece tied with spun yarn at intervals of 2 or 3 feet to the second lath from the bottom. A second layer is now put on one lath higher up, and is secured in a similar way to the third lath from the bottom, and so on until the top is reached; the last layer projecting over the top lath, so that when the frames are locked the ends may be twisted together to keep out wet.* When both frames are ready they are raised and locked. Forked uprights and a ridge piece may be added to stiffen the roof.

Each side of the roof may be made in one piece, or if large and inconvenient to more in two sections. The ends of the laths should project about 2 feet beyond the extreme rafters, and are supported by the framework forming the gable ends.† The latter are made and thatched in a similar way to the roof, and simultaneously with it, an opening being left for a door.

In order to give additional headway, the passage may be sunk ‡ with steps at each end, the earth being thrown to the eaves as additional protection, and to give more head-room when lying down. In very cold weather the whole interior of the hut may be excavated, fire places constructed,§ and, if the rafters be strong, some of the excavated earth may be thrown on to the top of the roof, a collar tie being added to strengthen it. It is however inadvisable, whenever it can be avoided, to excavate the floor of huts in this way.

Wattle and daub huts.—Walls may be constructed of wattle and daub, *i.e.*, continuous hurdle work daubed over one or both sides with clay, in which is a proportion of any fibrous substance, such as straw, grass, horse hair, etc., chopped into short lengths to prevent the clay cracking and opening as it dries. This mixture, which should be kneaded into the consistency of stiff paste, should be worked in with the hands. The side should be strutted at intervals to resist wind, and the roof may be carried on a ridge pole, which may be strengthened by uprights in the centre (*Manual of Military Engineering*, Pl. 64, Fig. 3).

Log huts.—With abundant timber, log huts may be constructed. No fastenings are needed beyond some wooden pegs to secure the rafters to the top logs. The roof may be constructed as described above, or the covering material may be of slabs of wood, bark of trees, etc. Bark may be got off trees in large strips by cutting round the tree with a knife at intervals, say, of 4 feet, then cut off the width required, and beat with a piece of flat wood to detach the bark from the tree.‖

* *Manual of Military Engineering*, 1905, p. 76; *Vide* Fig. 6, Pl. 63, *ib.*
† *Ib.* P. 63, Fig. 5.
‡ *Ib.* P. 63, Fig. 3.
§ *Ib.* P. 64, Fig. 1.
‖ See *Manual of Military Engineering*, 1905, p. 77.

Bamboo was used in the Ashanti Expedition, on several of our North-East Frontier Expeditions, and in Suakim, and made excellent huts. In the Nile Expedition sun-dried bricks were used and gave great protection from the sun.

A method of making a good form of straw mat for a bed is as follows :—Pickets are driven into the ground, the outside pickets being at a distance apart about 6″ less than the width of the required mat. A cross-bar is fixed about 2 feet from the ground. Several lengths of straw yarn are then taken and made fast about the middle of the cross-bar, at a distance of 5″ or 6″ apart and their ends made fast to the bar and to the other pickets. Handfuls of straw, rather longer than the width of the mat, are taken and pushed in between the yarns, the bar being alternately raised waist high and depressed to the ground, and passed inside and outside the end pickets, so as to form a hitch. Finally, the sides of the mat are trimmed to the right size by a sharp pair of scissors or a knife and the yarns finished off at either end with reef knots.*

The following diagrams, representing temporary shelters, explain themselves, and call for no detailed description.

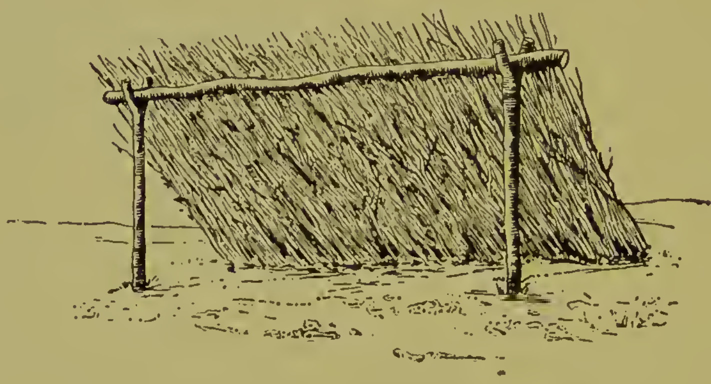


FIG 51.—Brush wind-break for Bivouac.

FIG. 52.—Arrangement of French bivouac.

* *Manual of Military Engineering*, 1905, p. 78; see also Pl. 65, fig. 1.

Circular wall bivouac.—"When no other materials than earth and brushwood are available, a comfortable bivouac for 12 men can be formed by excavating a circle with a diameter of 18 feet or thereabouts and piling up the earth to form a wall 2 or 3 feet high. The men lie down, like the spokes of a wheel, with their feet towards the centre as in a bell tent. Branches of trees, or brushwood stuck into the wall, improve the shelter."*

Temporary shelters may be erected by driving two forked stakes into the ground with a pole resting on them; branches are then laid resting on the pole, thick end uppermost, at an angle of 45°, and the screen made good with smaller branches, ferns, etc.† This is one of the forms of shelter which Gurkhas are so clever in erecting out of what *seems* to be impossible material.

Temporary shelters, billets, etc., of Japanese.—At the front the Japanese lived in *tent d'abri*. or holes dug in the ground, or in shelters constructed of any materials available. In the rainy season men lived in village houses which had not been cleaned from time immemorial. The dirt from floor to ceiling was swept away, old newspapers were pasted on the walls, and a solution of carbolic acid was sprinkled about. After finishing the sanitation of the interior, all refuse around the house was collected, removed and burnt. Bath-rooms and latrines were constructed and drains were dug. The villages were constantly inspected by medical officers. Amongst other things they suffered terribly from Manchurian flies, which were a disgusting plague. Covers had to be made for food, drinks, cups, bowls, chopsticks and tooth-brushes, to exclude flies.

In camps of any duration baths were arranged by sinking large Chinese pots in the ground, in these a man can fit comfortably. The Japanese most frequently occupied Chinese houses, which were previously medically inspected. In these a piece of the brick bed-oven two metres long was given to each man, and on which straw mats or quilts formed a comfortable bed. "Specially insalubrious villages, or those with a great number of infectious diseases, were not occupied—the troops had then to pitch camp." The shelters of the troops at the outposts, when they had to face for weeks the vigorous northern winter, with an average daily temperature of 30 to 36° below zero, were of earthen huts made in every available crevice and water-course, or consisting, when these were not available, of holes dug in the ground and roofed with straw mats, reeds, etc., the doors hung with tent flaps, and the floor covered with straw. They were made for two or three men or for whole squads, and heated by wood charcoal burned on old tin provision boxes, or reserve cartridge cases. Where practicable *kangs* were improvised by the erection of two low walls, overlaid with low stones

* *Manual of Military Engineering*, 1905, p. 74.
† *Combined Training*, 1905, p. 46.

jointed with lime, a fire being kept up at one end, and the smoke issuing at the other. The stone surface thus heated formed the sleeping place.

Billets.—Billets have several advantages by allowing of proper rest and shelter from weather effects, but they have also their disadvantages, not the least of which is the dispersion of troops they cause. Close billeting, allowing as many as possible to sleep in houses, the rest bivouacking, overcomes this disadvantage to some extent. "For the health of an army billets if available, and tactical considerations admit, should invariably be utilised in preference to making troops bivouac."

Hardening to night exposure necessary.—Soldiers of experience tell us how severely repeated night exposure affects the stamina of all but the very hardiest troops. One of the chief causes of its baneful influence is want of proper sleep and rest. Night operations prevent both sleep and rest and give rise to much hardship. It is probable, however, that in future campaigns, with modern weapons and methods, night operations will become increasingly more numerous. Hence the necessity of training our men to them.

Shelter tents—tent d'abri.—There is no special *tent d' abri* prescribed for troops of the British Army. Four excellent types of shelter-tents are described and figured in the *Manual of Military Engineering*, 1905, Sec. 192.

The *tent d'abri* for four men may be formed with three water-proof sheets laced together at the ridge. Blankets may be used in the absence of water-proofs (*Manual of Military Engineering*, Pl. 62, fig. 3). A wall of straw or reeds supported between sticks tied together at intervals may also afford temporary shelter (Pl. 62, fig. 4).

Shelter-tents are provided in some European Armies and in the United States Army. It usually consists of a piece of canvas or water-proof sheeting, which when united to that of another man, may be made into a shelter-tent. It is provided for usage of a purely temporary character, and is intended to afford protection from the elements whenever the employment of more burdensome shelter is impracticable. The shelter-tent camp, therefore, occupies a position intermediate between the simple bivouac and the more substantial tent encampment.

A tent similar to the shelter-tent was in use in the British Army in 1750, but was re-invented by the French troops in Algeria about a century later; the bedsacks which were issued in the latter service at that time being split open, fastened together in couples, and utilised as shelters.

In the United States Army the shelter-tent is light—a most essential quality—readily pitched, well ventilated, and never over-

crowded. By its employment the hardships of the bivouac are avoided, recourse to the cantonment system becomes unnecessary, and the command is rendered largely independent of the movements of the transport. It serves an excellent purpose in the protection of troops, not

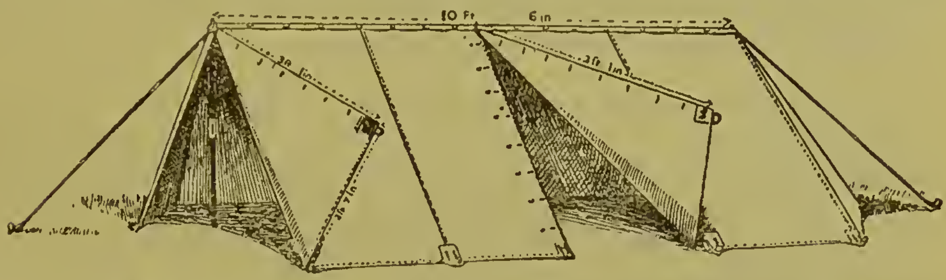


FIG. 53.—New style shelter-tent U.S.A. Two double sets are pitched together.

only when pitched upon the ground, but also when used as a roofing for habitations with solid walls. It is not, however, a sufficient protection for a winter campaign. As usually carried by the soldier, it is rolled around the blanket in the form of a long cylinder and slung from one shoulder to the opposite hip; the free ends being tied together with the guy rope.

While the shelter-tent has, in the past, been rarely employed in the German service, a model is now used consisting of a piece of waterproofed brown material 5 feet square, furnished with eyelets, button-holes

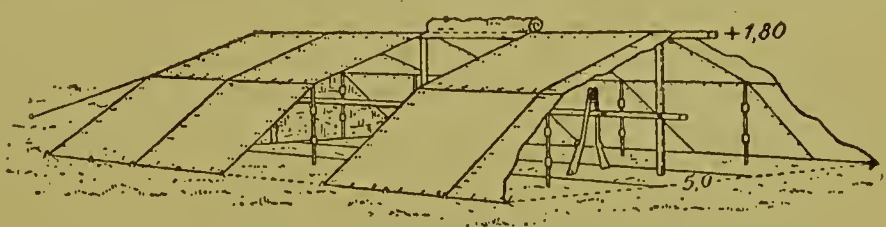


FIG. 54.—German shelter-tent.

and aluminium buttons, and having a weight of $3\frac{1}{3}$ pounds per man. During the march this tent can be used to protect the soldier against rain, being fastened around the neck and waist. Two men can pitch their squares together; but usually a number unite their canvas into one shelter. In the latter instance, four individual pieces are generally joined to make a single long sheet. This is supported at the middle by a ridge having a height of 7 feet while the ends are pegged to the ground at a distance of 16 feet from each other. Half-way between the central ridge and the pegs the canvas is supported by small uprights carried for the purpose. Sections similar to the above may be added indefinitely—each section readily accommodating four men. The canvas may also be pitched over a frame, so as to form a shelter with a roof and back but open at the front and sides. In fine weather or

summer the shelter-tent is not pitched, the men sleeping upon it. A shelter-tent somewhat similar to that of the Germans is used in the Spanish Army. Each tent is required to serve for the shelter of six men and has a length of 11 feet and a breadth of 7 feet. The Japanese troops, in the war with China, carried a shelter-tent of water-proof cotton 3 feet $3\frac{1}{2}$ inches by 4 feet 7 inches. The Russian shelter-tent resembles that of the German military service.

The Austrian Army has a somewhat different shelter-tent, weighing $3\frac{3}{4}$ pounds per man. It is made of cotton duck, each piece being lozenge-shaped and having a length on the side of $6\frac{1}{2}$ feet. The tent may be pitched so as to accommodate a large number of men, but usually only two men combine their canvas. Each piece of cloth is provided with an aperture at one obtuse angle, capable of receiving the bayonet and protected from tearing by a metal rim. The tent may thus be supported by the use of the rifle as a central upright, or small jointed rods may be employed for the purpose. When pitched, the tent forms a pyramid having a rectangular base $6\frac{1}{2}$ feet square and a height of 5 feet. It accommodates two men, or in an emergency three, and gives a sheltered area of 13 square feet. The use of the rifle as a support would seem to be highly inadvisable from a military standpoint.*

The water-proof sheet.—It is essentially necessary that all troops, British and Natives, on field service, be provided with water-proof sheets of canvas or other material, and this should always be part of their equipment. The Japanese considered it indispensable in the late war. They converted them into tents when necessary. "Without these little tents, KAWAMOWIA'S Army would not have reached Mukden. They accomplished a 25 days' march in an almost deserted country and with a Siberian winter temperature, which was never above 15° of frost. During the burning days of the battle of Liao-yang the reserves sheltered themselves under these little tents supported on rifles." In our Native regiments many now use one or other modification of the shelter tent formed from their water-proof sheets which they carry regimentally.

Bivouacs.—With the vast armies that will take the field in these days, it is highly probable that, as was repeatedly the case with both the Japanese and Russians, the force will, during halts, be dispersed somewhat in bivouacs as there are few places that could provide billets for such large forces.

Sites to be avoided for bivouac.—Large woods with undergrowth and jungle, low meadows and newly turned meadows or ploughed fields should be avoided if possible. Bivouacs are rarely adopted except in proximity with the enemy and when a condition of readiness is an

* MONSON'S *Military Hygiene*, p. 355.

imperative military necessity. Bivouacs are always trying to the health, but are often indispensable when concentration and readiness are required.

Many experienced military medical officers consider that men are better in health in the open during the ordinary cold weather than in tents. It is perhaps different when men have to bivouac for prolonged periods in inclement weather—then even many of the hardiest run down and lose stamina.

PART III.

PERSONAL HYGIENE.

A.—The Skin, Feet, etc.

Meaning of personal hygiene.—The phrase "personal hygiene" has a wide meaning, and refers to all those conditions of the body that can in any way affect health. *Personal cleanliness* refers to keeping the skin and all parts of the body clean, including the nails, mouth, teeth and throat. It is convenient in this section to consider also the immediate surroundings of the individual, and their effect on his well-being. The greatest reforms in sanitary matters in the Indian Army are to be effected by the attention of each soldier to all that concerns his personal condition and the state of his surroundings. If he recognises this and carries it out, he can as a rule promise for himself freedom from sickness. We shall now pass on to consider the ways in which the personal condition may be affected.

To enable us to understand the manner in which the warmth of the body is kept up and how clothes protect from changes of weather, and the use of washing and bathing, it is necessary to know something about the structure of the skin.

Structure of the skin.—The skin is composed of a *superficial* and a *deep layer*. The superficial layer is called the *cuticle*, *epidermis*, or *scarf skin*, and is that part which is raised by a *blister*, or when boiling water falls on it. The *deep layer*, called also the *cutis vera* or *true skin*, is made up of nerves and blood-vessels bound together by an elastic and fibre-like tissue having also in its structure involuntary muscular fibres. The superficial layer, on the other hand, is bloodless, and when damaged does not give rise to pain, nor does it feel heat or cold. The cuticle consists of many layers of very minute flat cells. These are always being shed from the surface in the form of scurf, but are as constantly being renewed by the true skin situated beneath. In some animals, as the snake, frog, and others, this skin is thrown off *en masse* periodically, and the same sometimes occurs in man after a few of the eruptive fevers, such as scarlet fever. The microscope shows that the cells of the deep layers of the cuticle are round, and these round cells become flattened as they approach the surface. The scales on the surface are hard, those in the deeper layers soft. There are millions of these flattened cells in a square inch of skin

Use of the cuticle.—In all those parts of the body that are liable to friction and injury, such as the palms of the hand and soles of the feet, the cuticle is thick. By constant use the cuticle becomes hard and horny. People who have always worn boots and shoes cannot walk on rough ground bare-footed without discomfort, as we see some bazaar children do, whose feet have become hardened. The blacksmith handles hot iron without pain, and the stone mason works in lime without corroding his flesh, because of the thickened cuticle of the hands. In the deeper layers of the cuticle there is a colouring matter consisting of small dark granules; the number of granules determines the varying complexions to different races. Between the true skin and the scarf skin is a layer called the *basement membrane*, which is a delicate gauze-like structure on which lies the layer of cells containing the colouring matter. Very superficial scratches do not bleed and are scarcely felt. When boiling water falls on the skin, the scarf skin is raised by the fluid which

accumulates beneath it and the true skin. When the blister bursts, the pink surface seen beneath it is the true skin which is very vascular and very sensitive. Some people are easily freckled on exposure to the sun—this arises from the patches of pigmentation in the deeper layers of the skin under the influence of sunlight.

Sweat glands.—Beneath the true skin are situated the roots of the hair and two sets of glands—one which secretes the sweat, and the other which secretes an oily substance that serves to keep the skin soft and the hair from becoming too brittle. The sweat glands, also called *sudoriferous* glands, from the Latin word *sudor*, sweat, are surrounded at their deeper parts by a large number of minute blood-vessels, from which they take that which is required to form sweat. Each gland consists of a minute tube, which at its deeper end coils up and forms a small spherical body called the *glomerulus*, and from this passes a wavy tube (the *duct* of the gland) to open on the surface. They have small narrow ducts which open on the surface of the body by minute orifices, commonly called the "pores of the skin." About two-and-a-half millions of these little pores are found on the skin of the body. Sweat is always being secreted. Sometimes it is formed so rapidly that it may be seen to ooze from the skin, but when we are cool and the amount of perspiration formed is small, we do not notice it, for it soaks into the horny layer of the skin and keeps it moist. This latter is called the *insensible* perspiration; it is constantly being evaporated from the surface of the body.

As the sweat glands are constantly at work and driving waste materials from the blood, it is very essential that we should keep their openings free by cleanliness of the skin. If the 'pores' are choked up with dirt the functions of the skin are partly lost, ill-health will result, and various diseases, besides those of the skin, may arise.

Sweat.—Sweat itself consists of a transparent colourless fluid holding in solution certain fats and volatile fatty acids, urea, free lactic acid, salt, chloride of potassium and other bodies.

Sebaceous glands.—The second set of little glands in the skin are called *sebaceous glands*, because they secrete an oily or greasy substance called *sebum*. These glands usually open near the root of a hair. The fatty material they form is conveyed to the root of the hair, and along it to the surface of the body. On the surface it tends to decompose, giving rise to an offensive odour, and forming compounds in the shape of fatty acids which, if not washed off, irritate the skin.

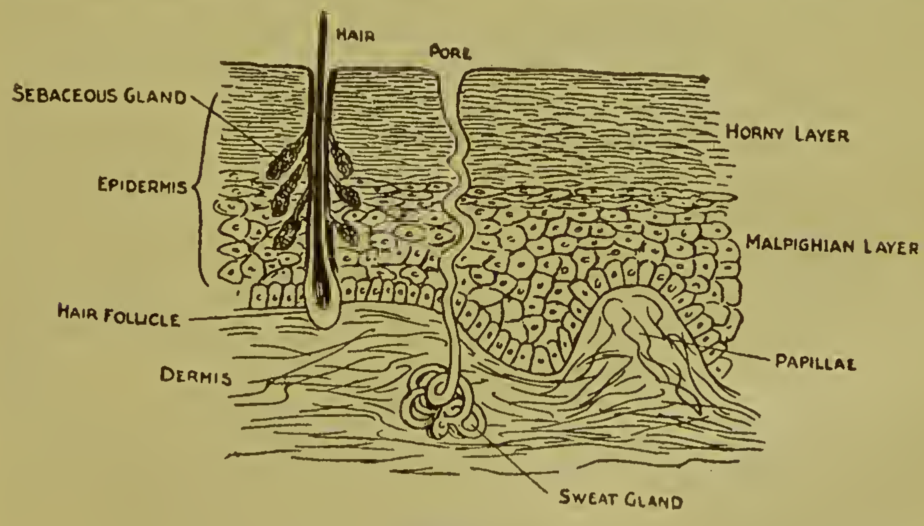


FIG. 55.—Diagram of skin.

Functions of the skin.—The skin is one of the most important organs of the body. One of its special functions is that of excretion*—it gets rid of a certain amount of poisonous material from the blood ; this is effected by the sweat glands. The skin of an adult throws off about 20 ounces of water daily, but this quantity varies with the season of the year, nature of the climate, occupation, etc. In the hot weather and during severe exercise, for instance, this quantity may be lost by the skin in an hour. But sweat is not all water. It contains solid poisonous waste matters, which, if not washed off from time to time, decay on the surface of the body. The skin further, by a complicated mechanism, serves to regulate the temperature of the body. It forms a sensitive covering for the whole body, protecting the deeper parts from injury. It also plays the part of a sensient surface for the reception of sensory impressions. The skin is capable of absorbing certain bodies from the surface; the lead poisoning which occasionally occurs in house painters and printers is due to this. The ship-wrecked sailor in a boat in the open sea soaks his clothes in the sea and puts them on to assuage his thirst. Small abrasions on the surface permit of various bacteria gaining access to the system, and this is one of the ways in which certain infectious diseases and blood poisonings are produced.

The skin as a regulator of temperature.—Heat is lost from the body by being given off to the air by convection, conduction and radiation, provided that the temperature of the surrounding air is lower than that of the body. Radiation, however, is not an important source of loss of heat except in the cold weather, as it takes place very slowly and is comparatively small in amount. If the skin were covered by an impermeable varnish, loss by radiation would take place very rapidly, and animals so treated die from loss of heat. Heat is used up by the evaporation of the sweat, and this is an important point. A large amount of heat is required for the conversion of water to the gaseous state, and as the air surrounding the body is a bad conductor, most of this heat must be supplied by the warm surface of the body itself. As there is a close network of capillary blood-vessels lying immediately below the surface of the skin, the blood in these becomes cooled, and this, on its return to the heart and lungs, causes a general lowering of temperature throughout the body. The whole of this mechanism of heat regulation is under the control of the nervous system which acts (1) upon the blood-vessels and (2) upon the sweat glands. Under normal conditions the two sets of nerves going to these structures work together, but they may act independently ; in some cases of fever this takes place, as when we have a flushed face with a very hot dry skin, or in collapse, when we have a bloodless skin with profuse perspiration. The heat of the body is practically always the same, summer and winter. The internal temperature of the glass-blower and the engine-stoker, who

* By *excretion* is meant the gathering up or separation of waste poisonous substances from the blood, and throwing them off from the system.

work before furnaces, is not higher than that of other people, because the heat regulating mechanism of the body enables them to throw off the heat by perspiration and evaporation from the surface. Charbert, "The Fire King," used to go into a hot air room in which the temperature was 400° F. and remain there for several minutes, yet his temperature did not rise beyond normal. The tissue of the body, especially the muscles, liver and brain, are always producing heat, because in them there is constantly in operation a slow burning or oxidation. Man is able to live in all climates because his blood always keeps at about the same temperature ; the Esquimaux, who lives in the ice and snow of the North Polar regions, is as warm as the African living under a scorching tropical sun.

The skin of Europeans in India, is particularly sensitive to changes of temperature, and this accounts for the great susceptibility to chills. The skin is supplied with a large quantity of blood, and in India there is greater amount of perspiration and more evaporation from the surface. Any abrupt stopping of perspiration or evaporation is liable to be followed by derangement of the bowels, liver, or other internal organs. Chills are responsible for many of the conditions of ill-health occurring in India. It is necessary to clothe ourselves so as to keep the surface of the body at a uniform temperature.

The hair.—Hair is an appendage of the skin which correspond to the fur and wool of mammalia, and the feathers of birds. Each hair consists of a *body* or *shaft*, and a *root* or bulb, which is inserted into the tissue of the skin, in what is known as the *hair follicle*. The shaft is divided into an external or *cortical* portion, and an internal or *medullary* portion. The cortical portion consists of condensed cells arranged so as to present a fibrous appearance, and is surrounded on the outside by a layer of minute epithelial scales which give certain characteristic markings. The medullary part consists of an irregular row of cells occupying the centre of the hair. The main substance of the shafts consists of pigmented cells which gives the colour to the hair—the grey hair of old age is due to the absence of the pigment. The root of the hair is enlarged at its extremity into a knob, into which projects a vascular little mass (*papilla*) from the true skin. A small blood-vessel enters the bulb of the root of each hair and supplies it with nutrition. The hair follicle consists of two parts, one external, continuous with the epidermis, called the *root-sheath*, and the other internal, continuous with the true skin. A small bundle of involuntary muscular fibres is attached to each hair follicle. When this bundle contracts, as it does under the influence of cold, or during the shivering stage of ague, the hair is erected and the whole skin is roughened ("goose skin"). It is the presence of these small muscles attached to the hair that causes the hair of a dog or cat to stand up when it is angry. The root of the hair is also supplied with nerves. The hair of the head is naturally lubricated with an oily substance secreted by the

sebaceous glands; this natural oil keeps the hair soft and smooth, and removes the necessity of using artificial hair washes, hair oils, or other greasy messes for the hair.

The hair protects the head from heat and cold, and helps to shield the head and other parts it covers from injury. It is found in almost all parts of the body, except the palms of the hands and soles of the feet.

The soldier's hair should always be kept short, washed regularly, and combed and brushed twice a day. If this is not done the secretion of the sebaceous glands get clogged on the surface of the scalp and collects dust, dirt and germs of various kinds, which may set up much irritation or cause skin diseases. The hair brush should also be washed in a basin of cold water with a teaspoonful of washing soda. It is dried by shaking and swinging it round and then putting it out in the sun. This should be done every fortnight.

The nails.—The nails are modifications of the skin, the hard part consisting entirely of thickenings of the cuticle. Every nail lies in a depression, called the *bed of the nail*, the posterior part of which is overlapped by epidermis and called the *groove of the nail*. The dermis beneath is beset with longitudinal ridges instead of papillæ; these are highly vascular, but the curved part of the nail (*lunula*) is less vascular. The nails serve the purpose of protecting the tips of the fingers and toes; they are free from pigment.

When dirt collects beneath the finger nails it should be removed; this removal is best carried out by a nail brush, soap, and water, assisted by a nail scissors, or penknife. Dirt under the nails is a favourite place for microbes to breed in. The finger nails should be cut short and trimmed. The toe nails should be cut nearly square.

The hands should be kept clean—whitlows, boils and various eruptions occurring on the hands are usually the result of dirt attacking the deeper parts of the skin, nails, etc.; dirty hands may also infect the food. It is necessary for health that we should sit at our meals with clean hands

Care of the feet.—The *feet* require special attention; they perspire freely, and become offensive if not frequently washed with hot water and soap, and the socks changed daily. The sweat of the feet dries up on the surface, undergoes fermentation, irritates, causes local eruptions of different kinds, or general soreness. The feet should whenever possible after a march be thoroughly washed with soap and water, and a clean pair of socks worn. If this cannot be done, the feet can at least be wiped with a wet towel. Wearing the socks turned inside out is better than allowing the feet to soak in the putrefying sweat. The socks should be washed frequently.

The number of men that fall out from sore feet during the first week of a long march varies considerably in different regiments—even amongst regiments living, working and training under the same conditions—and whenever an unusually long march of, say, 20 miles has to be undertaken, this number is increased.

It has been stated that our Army suffers more from inefficiency due to sore feet than any European Army. One is unable to say how far this is true, but it is certain that the regulations regarding the care of the feet and state of the boots are more explicit, and the discipline on these points more severe, in the German and French armies, than in our own. "If it be an uncontested truth that the efficiency of strategic formations depends upon the manner in which they are accomplished, if it be true that modern warfare entails on infantry increasing marching and counter-marching, if it be true, consequently, that only those most fitted for marching are the armies which have the best chances of victory, then the army which is least capable of marching and which drags on towards the enemy with half its ranks filled with men with torn and sore feet, is already condemned beforehand to defeat, however well armed it be. Rational marching are the *alpha* and *omega* of the infantry." *

Hygiene of the feet.—The hygiene of the feet may be referred to under two headings—(1) that of the feet and (2) that of the boots. Regarding the hygiene of the feet it is unnecessary to state that the medical recruiting officer, when passing recruits, should be specially careful that no man with defective feet is posted to the infantry. Recruits should from the outset be taught how to look after their feet, and with this object they might on enlistment be provided with a printed card of instructions as to how this is to be done.

Chiropodists—one per company.—It is worth considering whether we should have a system of regimental chiropodists—men who have been instructed as to the best method of cutting corns and toe-nails, and who are made familiar by teaching with all the smaller affections of the soldier's feet and how to treat them. The addition of a chiropodist to each company would greatly facilitate this. In the Native Army the ordinary company barbers should also be instructed as to how to deal with ordinary sore feet, shoe-bites, ingrown toe-nails, etc.

The company chiropodist's duties should be defined, and every week during peace times he should inspect the men's feet, their boots, and socks, note any tendency to corns, blisters, surface soreness, ingrown toe-nails, etc. The causes of the special conditions should be explained to the men, together with the way to prevent them. When proceeding on the march men might be given one of the numerous preparations for hardening the feet, and the men who are known to have any special tendency to blistering, ingrown toe-nails, corns, etc., should, when on the march or on manœuvres, see the chiropodist daily until the tendency disappears. Under such circumstances men can have no excuse for falling out from "sore feet."

Various lesions may arise from long drills, such as œdema or swelling of the feet, inflammation of the toes and covering of the bones of the feet following on fatigue, etc.

* Dr. Klefberg quoted in the *Journal of the Royal Army Medical Corps*, June 1906.

In the Native Army company or squadron barbers are moderately skilful in dealing with corns and cutting toe-nails, and a few lessons by the regimental medical officer would considerably enhance the value of the barber's work.

KLEFBERG says : " A hospital orderly specially trained in diseases of the feet should be permanently appointed for this exclusive duty with each company ; surprise inspections should be made frequently, when both the feet and boots should be carefully examined, and any neglect treated as a military crime ; only regulation boots and socks should be allowed to be worn ; and these are to be made on natural models. To effect a quick distribution of easy fitting boots on mobilisation, each man's small book should note the length, width, and circumference of such boots ; these measurements should be legibly marked on the side of the boots in store for mobilisation purposes. Patients suffering from inflammation of the toe joints, or from periostitis (inflammation of the covering of the bones) should be put to bed ; a soldier who by reason of this condition of his feet is unfit for infantry should, instead of being permanently invalided, be posted to some other branch of the service." The recruit should have feet in every way free from defect and deformity, and if properly looked after, they should improve and be better fitted for marching year by year.

There is no system of regimental or company chiropodist in the German Army, so that efficient results have to be attained solely by individual effort on the part of the soldier, taking full advantage of the regimental and company boot-makers, constant supervision of the feet by company officers and medical officers, and deterrent punishment in case of neglect. *

Inculcation of habits of cleanliness.—It is necessary to reiterate the necessity of cleanliness of body and clothing by regular bathing and washing of clothes. From the date of his enlistment the necessity of personal cleanliness should be inculcated into the recruit, until the regular habit of being clean in his person and clothes becomes mechanical. The facilities for these operations on field service are often limited, especially when water is scanty and at a distance. Yet medical officers with corps should insist that every available opportunity is taken advantage of for bathing and washing the clothes, especially clothes worn next the skin. The numerous minor ailments—eruptions, irritations, parasitic cutaneous maladies, etc., arising from the unwashed skin, add to inefficiency. The bullets of the enemy when we have clean skins and clothes have little to be feared, unless they injure large joints or vital organs. The reverse is the case when the skin laden with septic micro-organisms is damaged. Modern surgery can do much, but it is incapable of assuring recovery in the case of wounds

* Capt. C. K. SYLVESTER BRADLEY, R.A.M.C., *Journal of the Royal Army Medical Corps*, July 1908, p. 78.

surrounded by and impregnated with all the potentialities of septic infection. We insist on the necessity of this cleanliness of skin and clothes in our annual course of first aids to the injured, and we point out the innocuousness of ordinary bullet wounds and sword cuts in the presence of our first field dressing, provided that no septic germs are introduced through the skin and clothes and no vital parts damaged.

Care of the teeth.—The Native soldier does not as a rule need to be warned about the necessity for keeping his teeth clean; but in certain conditions of the gums and mouth (referred specially to later on), in which the necessity for cleanliness is urgent, he is liable to neglect doing so. The necessity of keeping the teeth and mouth clean should be insisted on with our European troops. The teeth should be cleaned every morning and night with a toothbrush (or its substitute in the Native Army) and some carbolic or other tooth-powder used If the teeth can only be brushed once a day, the best time to do so is just before going to bed. This brushes away all the food particles that lodge between the teeth and in the mouth. This together with rinsing out the mouth twice a day is one of the safeguards against dental caries. The teeth should be brushed with sterilised water.

. Foul mouths and bad teeth add considerably to the impurities of the air of barrack-rooms and tents. The mouth is naturally inhabited by germs, and is really difficult to keep perfectly clean, but efforts to do so should be made twice a day. This helps to keep the mouth sweet, the teeth free from decay, and gets rid of many of the disease germs that are such constant inhabitants of the mouth.

Whenever any decay of the teeth is observed or toothache occurs, the victim should report sick so as to have the teeth attended to. The factor of decayed teeth as a rule only tells on men during a moderately long campaign. Serious attention does not seem to have been drawn to this condition until the South African Campaign, which, because of its length, affected men with bad teeth. The Indian Government, at considerable cost and much liberality, determined to improve the condition of our soldiers' teeth, and permitted all men in need of artificial dentures to be provided with them. For various reasons the benefit derived does not appear to be in any way commensurate with the cost, and there can be no doubt that the liberality and consideration shown to men suffering from defective and decayed teeth has been in many instances abused.

Sanitary regulations and the laws of personal hygiene cannot be engrafted when on field service; they must be inculcated in peace times. "The whole sanitation of an army depends in the ultimate issue, on the individual effort of each person in that army." Our men should be taught to pride themselves in obeying all general sanitary orders connected with the barracks and camp, and all instructions given them regarding personal hygiene. In February 1904 in the Japanese Army,

a pamphlet entitled *Precautions on Individual Sanitation* was published and universally distributed amongst the rank and file, medical officers gave lectures on the subject of individual sanitation at the front once or twice a month. Many of the things recommended in the pamphlet were found to be useless in Manchuria and Korea. In May 1905, another pamphlet called *Precautions against Cholera and Plague* was similarly distributed. One of the articles issued to troops was a creasote pill—its use, once or twice a day was compulsory in all ranks, and their medical officers attributed the comparatively small numbers of enteric fever and dysentery cases to their use. Nearly 4,000,000 of these pills were made and used.

Personal hygiene should form part of the daily life of the soldier, and he should take a pride in avoiding all conditions and habits likely to cause sickness, and in adopting all possible means of preventing disease of any sort.

B.—Bathing.

We have seen that the normal secretions of the skin tend to accumulate on its surface and make us dirty; but the skin may be soiled in other ways—by the dust of the air and by coming into contact with such impurities as we may work in. All these have to be removed; if they are not, the functions of the skin are imperfectly performed and its work has then to be carried out by other organs. If the blood-vessels in the true skin are contracted by cold, they cease to supply the fluid and other bodies that go to form sweat. If the waste matters that are usually removed by the sweat are locked up in the body, we are rendered liable to various forms of disease. The pores of the skin, when in action, help to remove certain impurities from the surface which have been thrown off from the blood. The skin, in many diseases, is the main channel for getting rid of the disease poison.

Necessity for bathing.—All these facts point to the *necessity of bathing from head to foot at least once a day whenever this is possible.* The whole of the wonderful functions of the skin may be deranged, interfered with, or even suspended, through neglect of frequent ablution; inattention to this hygienic requirement seldom failing to produce disease.

Time for bathing.—The proper time for bathing is just after rising in the morning. At that time the body is warm and can tolerate cold water better than at any other period of the day. After the night's rest, the body needs bracing, and the nerves, rendered sluggish by the night's repose, require gentle stimulation.

Effects of bathing in cold water.—The system, when in health, is strong enough to resist the mild shock produced by moderately cold water. The cold bath in the morning refreshes, arouses energy and fitness to go through the day's work. The first effect of the cold water is a slight shock which is rapidly followed by a

pleasant general glow of warmth, and a feeling of increased vigour. It helps the oxidising process, and hastens the functions of the internal organs. But a cold bath is not safe for all persons. Delicate people, those who are recovering from sickness, those subject to chills, ague, or fevers of any description, to diarrhœa and dysentery, and other internal complaints, should avoid the cold bath. After a cold bath there should be a speedy reaction. The cause of this reaction is that when the surface of the body is cooled by cold water, the blood, driven into the heart and other vital organs, excites them to more vigorous action, and being thrown back to the surface it reddens and warms the skin ; it is to this pleasant and invigorating influence that the good effects of the cold bath are due. On the other hand, if the skin be heated, as it is in the hot bath, the blood comes to the surface in abundance, less goes to the heart, and other internal organs ; the blood-flow is lessened and langour ensues. A dash of cold water is refreshing at the close of the warm bath to counteract these effects. If a cold bath is succeeded by a continuous chillness and depression, it indicates that either proper means were not taken to bring on this reaction, or that the circulation is not strong enough to stand it ; under these circumstances, the cold bath should not be indulged in.

After a cold bath, before dressing, the whole body should be thoroughly rubbed with a coarse dry towel or other cloth. The establishment of the reaction is an essential part of the cold bath—without such reaction the cold bath is always harmful ; with this reaction the cold bath is invigorating and health-giving. This will soon be followed by a pleasant glow. A cold bath should not be taken for at least an hour before and two hours after a meal, otherwise it would interfere with digestion. A cold bath should never be taken when the body is fatigued by exercise or heated ; a warm bath or a thorough rubbing down is then safer and more refreshing. A cold bath should never last longer than *five minutes*, and usually two or three minutes will be sufficient. Elderly people benefit more by the tepid than by the cold bath. We should leave the water immediately there is the slightest feeling of chilliness. Those who are subject to giddiness, faintness, palpitation, or cramps, should be cautious in indulging in cold baths. Those who have suffered from malaria, congestion of the liver, diarrhœa, dysentery, or are inclined to be stout, and those of advancing years, should bathe in warm water..

No bath is complete without a thorough rubbing down of all parts of the body subsequently ; this has a decided effect in improving the circulation of the blood.

Necessity for using soap.—*Soap* should be used frequently. It is indispensable for any bath taken for purposes of cleanliness. Some of the waste matters that cling to the skin are of a fatty nature. Fat does not combine with water, but soap easily mixes with the greasy material secreted by the sebaceous glands, uniting with it, and thereby enabling the water to wash it off. Soap is made up of fat or oil, combined with an alkali, which is usually soda, potash, or lime. In all soaps there is a certain amount of free alkali (that is, uncombined with the oil or fat), so that when soap is rubbed with water on the body, the spare alkali combines and forms a lather with the fat of the surface, which is then easily removed. Cheap and good soaps are now made in many parts of India and there is little excuse for not using them.

Frequent ablution or immersion of the body in water is one of the best ways of keeping free from disease; indeed, we cannot keep in perfect health if we neglect this. A frequent change of clothing helps to maintain the body in a clean condition; but this latter can only be perfectly effected by a daily bath. The scale-like particles from the outer layer of the skin are constantly falling off and becoming entangled in our clothes, and the underclothes wipe off some of the skin dirt, which remains in the meshes of the clothes; we should therefore change our clothes (particularly our underclothing) frequently, and they should be thoroughly washed before being again used. Under ordinary circumstances it is well to wear light coloured material near the skin; we can then *see* when it is dirty.

In the hot weather owing to the increased activity of the sweat glands a daily bath is required. Bathing by immersion is not always possible on account of the scarcity of water or lack of facilities. The shower bath has a great deal to recommend it in cantonments. Kerosine oil tins may be perforated and placed on a shelf arranged 6 or 8 feet from the floor and the bather may stand upon a wooden or bamboo rack raised a few inches off the ground. Such a shower bath may be easily improvised.

When water for a full bath is not available, the use of a wet towel thoroughly rubbed over the skin including the armpits, fork, feet, and toes should at least be adopted. It is specially necessary to keep the areas between the thighs and buttocks clean and the hands and nails clean. Cavalry and mounted men generally should wash the buttock and fork, and always have a supply of boric acid powder to apply when any redness from rubbing arises.

The water used for baths should be clean. Whenever the source of the water is not reliable, the water should be boiled and allowed to cool down to the required temperature. This destroys all germs and parasites that may attack or even penetrate the skin (embryœs of hook-worms, skin disease germs, etc.).

All swimming baths should be provided with a shower bath, which should be used first, the external genital organs and parts between the buttocks being thoroughly washed before entering the swimming bath.

Men should not be allowed to bathe in dirty, stagnant or muddy ponds or pools; there is practically never any harm in bathing in running water.

The hands should invariably be washed before meals. The nails should be repeatedly cleaned and trimmed. Unclean nails and hands are a common source of infection. The finger nails are best cut semi-circular and the toe-nail square. Many minor ailments such as boils, whitlows, inflamed skin, various eruptions, such as eczema, etc., affecting a man's fighting capacity, are due to irritation from dirt. All these are points which should be inculcated into recruits and young soldiers (*K. R.*, 1908, § 112).

C.—Clothing.

Hygienic Considerations.

The chief points in connection with the clothing of the soldier are—that it should be a non-conductor of heat, capable of absorbing moisture, permeable to air and water, and that it is durable.

Objects served by clothing.—The main objects of clothing are to cover the body and to protect from external influences; these influences are chiefly cold, heat, and damp. Clothes serve to prevent the heat of the body being lost too rapidly, to maintain a uniform or equable temperature on all parts of the surface of the body, to prevent the action of the sun on the skin and body, save the surface of the body from injury and keep out rain. Our clothes should also be able to protect us from the attacks of mosquitoes. Many of the diseases from which we suffer are due to changes of weather and imprudence regarding our clothing during these changes. Cotton clothes, for instance, would be altogether inadequate in the cold weather, and would lead to chills, colds, coughs, fever, diarrhœa, etc. The nature of the clothing we wear ought to vary with these external influences—that is, with the weather. The changes of weather are extreme in many parts of our Indian Frontiers, and these changes should cause us to wear suitable clothes to meet these variations. The only exception to this rule is the use of woollen or flannel clothing; flannel may be worn with benefit all the year round, it is a good protection against all sudden meteorological changes. Suitable clothing in winter serves to maintain the warmth of the body and to exclude the external cold. In summer, on the other hand, suitable clothes serve to keep us cool; they should not absorb the rays of the sun, and should permit of the radiation of the heat of the body. The clothing should be capable of absorbing perspiration. We can readily apply these essential conditions to the different kinds of wearing apparel.

Clothing to some extent interferes with *direct* radiation of heat to the surrounding air from our bodies, but a certain amount of radiation to the clothes does take place, and then from the clothes this heat is radiated to the air. Clothes likewise conduct away heat from our bodies. What clothing does is to render the processes of radiation and conduction of heat from the body more even and gradual, and so one of its functions is to prevent the danger that would arise from a sudden change of atmospheric temperature. The diurnal variation of atmospheric temperature in India is frequently 30 or even 40 F., and clothes protect us from the dangers that such changes may be associated with. They also prevent the great outside heat passing directly to the body. Clothing also, by protecting the blood-vessels and nerves of the skin from the effects of sudden changes, helps the skin in carrying out its important functions. A warm still air feels warmer to our skin than a moving air of the same temperature, because in the latter case a large quantity of air comes in contact with the skin and removes more heat by increasing evaporation.

The heat radiated from the clothes will depend on the rapidity with which heat is conducted from the surface of the body. The amounts of conduction and radiation of heat will vary much with the nature of the material and its colour,

The extremes of conductivity are represented in linen and fur. If linen=100, then wool=60. Hence woollen material is a worse conductor than either linen. Radiation is more rapid from linen than flannel.

Excess of clothing.—It is quite as great an error to be overburdened with clothes as to be too lightly clad. An excess of clothes renders us more liable to chills when we expose ourselves. Further, too much clothing impedes the freedom of action of the limbs. We should never wear tight clothes round the chest and neck. The head-dress should be light, and yet sufficient to protect us from the heat of the sun. The clothes worn during the day should, if possible, not be worn at night in bed. The clothes we have been wearing usually require to be aired, sunned, and dried, before wearing them again.

Changes of clothing.—In certain parts of our Indian Frontiers at particular seasons it is cold at night and warm during the day. In such places, the same clothes are not suitable at both periods. If we chance to get wet in the rain, or have perspired so profusely as to moisten our clothes, we should change the damp clothes for dry ones as soon as possible. If this cannot be managed, we should keep moving about briskly until our clothes are dry. Sitting down, or lying in wet clothes, is liable to bring on malarial fevers (under certain circumstances), rheumatism, diarrhœa, or other complaints. If we reach camp in damp clothes after a long march, we should not immediately expose ourselves to cold air by discarding our heavier outer garments. We should not sleep in damp sheets or damp bedding of any description, as this may lead to one of many serious diseases.

Tight and unsuitable clothing.—No part of our dress should give rise to pressure or constriction of any kind. In this respect, the dress of the inhabitants of India is superior to that of Europeans coming to the country. Tight cravats and collars constrict the neck, and prevent the free flow of blood; they may also give rise to headache, giddiness, and sometimes even to fainting. Neither the chest nor the abdomen should be in any way squeezed by constrictions of any description. All parts of the surface of the body, except the head, should be equally clad. Whatever changes occur in the clothing regulations, no part that is covered during the day can remain uncovered at night, except at the risk of health. All the clothing of the soldier should fit moderately loosely so as to allow freedom of movement in every part of the body, otherwise the mechanical work done in marching, etc., is increased.

Sufficiency of clothes.—After severe exercise it is always wise to put on some extra clothing at once. Never change the clothing abruptly from very heavy and warm garments to cool ones, unless the change of weather be abrupt. Under all circumstances, the clothes should be sufficient to keep us comfortable, neither unpleasantly warm nor too cool; in the case of delicate, feeble and convalescent people, whose circulation is weak, this precaution is specially necessary.

Fabrics of clothes.—Clothes are usually made of one of the following fabrics :—*Linen, cotton, wool and silk.*

Linen.—*Linen* is soft to the touch, and is a good conductor of heat, hence it is pleasant for summer wear. When we are perspiring it is very apt to chill the surface too rapidly, hence it should not be worn next the skin.

FIG. 56.—Woollen fibres.
(Magnified 340 diameters.)

FIG. 57.—Cotton fibres.
(Magnified 340 diameters.)

FIG. 58.—Silk fibres.
(Magnified 340 diameters.)

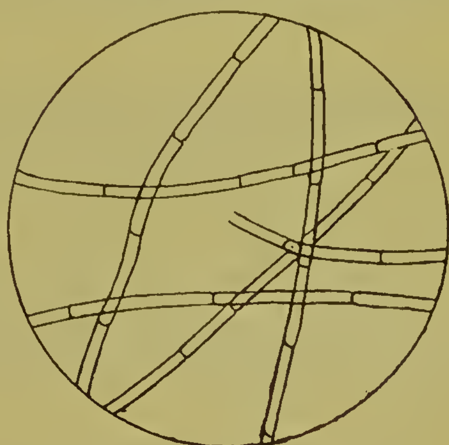


FIG 59.—Linen fibres.
(Magnified 340 diameters.)

Cotton.—*Cotton* is not so good a conductor of heat as linen, nor does it absorb moisture so readily. It is pleasant for hot weather wear, and perhaps gives a slightly better protection against chills than linen.

Woollen material.—*Woollen* materials absorb a considerable amount of moisture and thus protect from chill by preventing cooling of the body after exercise; they contain twice as much air in their

meshes as cotton; they are bad conductors of heat, and protect the wearer from sudden changes of weather. Woollen garments ensure the maintenance of an equable surface temperature better than any other fabric. Wool and flannel can absorb much large quantities of water than linen or cotton, and therefore take much longer to become saturated and so converted into good conductors through the water in their meshes. Experience has taught us that it is the best material for wear, and one of the best preservatives against illnesses generally in all seasons. Wool has, however, several disadvantages—for example, it becomes hard and shrinks on washing, and so loses part of its absorbent properties. This can be prevented by using soaps free from any excess of alkali, as most of the "washing soaps" are. The right way to clean woollen clothes is to wash them in warm water, using a good soap containing little alkali. Some soaps are made containing a small amount of petroleum, which adds considerably to their cleansing properties. The washing should be done rapidly and the articles dried quickly. Neither very cold nor very hot water should be used.

Linen and cotton in the presence of moisture rapidly lose their porosity, become saturated, their interstices filled with water, and as water is a better conductor of heat than air, they cool the surface more quickly. Linen, though much more expensive than cotton, has practically no hygienic advantages over cotton, and has no special feature to recommend it as part of the soldier's clothing.

Jaeger wool.—The highest perfection, however, in the material for a campaigning dress in hot climates would seem to be that introduced by Dr. Jaeger. This inventor has supplied the public with various kinds of his woollen sanitary clothing, one kind being adapted for the tropics. Jaeger woollen material has been introduced in the German Army, in which no linen is worn, and in which wool is everywhere in contact with the skin. This material is so manufactured as to be perfectly unirritating to the skin; it preserves an equable temperature round the body; the shape and arrangement of the constituent hairs of the texture provide for the escape of moisture by capillary attraction; and they act as the conductors of the various fluid impurities, decomposing fatty acids, etc., from the skin. It would seem that this sanitary wool clothing is exactly the clothing wanted for campaigning in hot climates, in which, as we have seen, alterations between the day and night temperatures so frequently come into play in the production of disease.

Flannel is an excellent material for wear in India, and even in the hot weather the thinner varieties of flannel are the best garments for wear.

"It is not necessary, however, that underclothing should be of pure wool. For hot climates it is difficult to get this either thin enough or soft enough to be comfortable, but various mixtures of wool and cotton and loosely woven clothes materials can be had which have these advantages while being cool and soft." Woollen material is now largely mixed with cotton which prevents its shrinking and makes it more durable.

The warmth of clothing largely depends on the amount of air contained in the meshes between its fibres; fine, loose, porous cloth, with plenty of nap, is best for winter wear. Heavy clothes are not necessarily the warmest. Furs are the perfection of winter clothing in very cold countries, since they combine warmth with lightness. Within limits, two light, warm, woollen garments, one over the other, are warmer than a single heavy one, as there is between them a layer of non-conducting air.

The special property of wool as a clothes fabric is due to the fact that it holds in its meshes an oil or fat, that when blended into clothes its meshes contain air which acts as a non-conductor of heat, that is, prevents heat passing from the body, and cold penetrating to the body from outside. After a series of improper washings the natural fat in woollen material is dissolved or crushed out of the fibre so that it loses many of its original properties. The unmerciful way in which the *dhobies* of India wash woollen articles brings about this state of things very rapidly.

Wool is destroyed by soaking in boiling water. All that is required is to put it into tepid or cold water and use good soap. These are articles however rarely used by ordinary *dhobies*, who beat the life out of flannel in a short time.

Many men, however, are unable to tolerate flannel next the skin, and in those in whom it predisposes to attacks of prickly heat, it is indispensable to use some form of gauze vest beneath it. A mixture of wool and silk constitutes an excellent combination particularly for protecting the surface.

Various forms of cellular cotton clothing have in recent years become very popular and many medical officers consider them to have certain special properties that make them suitable for hot weather wear.

The material called 'flannelette' is a very poor and flimsy type of woven cotton. It soon becomes very hard and non-absorbent. It is highly inflammable and should never be used.

Prickly heat.—Prickly heat is an annoying irritation of the skin caused by excessive sweating. It is very itchy, induces scratching, which intensifies the irritation. To prevent it the under-garments should be changed frequently, baths should be taken regularly and no irritating soap used. A useful powder to soothe the irritation is one of one part of boric acid and two parts of starch. When the skin is too sensitive for pure wool a mixture of wool and cotton or of wool and silk may be substituted.

Colour of clothing.—The amount of heat absorbed from without varies with the colour of the clothing. Dark substances will absorb more heat, and are therefore warmest when the external heat is great. This is why, on a hot weather day, a black-coloured coat in the sun is almost unbearable. Further, dark clothes radiate much heat; therefore in winter they tend to abstract heat from the body. Light-coloured clothes reflect more of the sun's rays, hence they are cooler in summer than dark-coloured clothes.

Dark-coloured clothes absorb more light than light-coloured, but they may be good or bad conductors of heat according to the nature of the material. White reflects light rays and heat rays, hence it is a poor absorber of heat. Next to white the least absorptive is grey or pale yellow, then dark yellow, light green, red, dark green, light blue and black. The influence of colour is only exerted on the surface,

hence, although it produces considerable effects on the texture, it has little influence on thick material. Grey is the best colour for soldiers' clothing, *khaki* next best; in regard to heat absorption these two colours are about the same.

Underclothes.—Under-garments should be made of materials which are light in weight, absorbent, non-conducting as to heat, and non-irritating. No one fabric possesses all these qualities perfectly. Underclothes should be of some sort of light woollen material. All underclothing worn during the day should, when practicable, be taken off at night. The sweat and dirt of the skin soak into the clothing. Coloured flannels, worn near the skin, have no special virtue in protecting from cold, on the other hand, they have disadvantages. For instance, they do not show the dirt, and may appear clean when saturated with the waste matters from the surface of the body. Further, some brightly-dyed flannels contain colouring matters which are injurious to the skin, creating different kinds of eruptions. Some of these dyes are prepared from arsenical pigments, and may, therefore, be poisonous. We should remember that coloured clothes, as well as white ones, rapidly absorb perspiration, and for this reason soon become dirty; they should, therefore, be changed and washed as frequently as clothes of light colour. All underclothes should after being used either be washed or aired in the sun. It should be always possible to have a clean shirt and a pair of drawers for use at night. Socks become dirty sooner than any other covering. Men should have two pairs in use and two pairs at the wash, one pair is required for morning wear and the other for evening use.

Meaning of "warm" and "cool" clothes.—One of the objects of wearing clothes is to keep our bodies at an even temperature. Clothes are spoken of as "warm" and "cool," but all clothes are of the same temperature. If we wish to keep the tea in a teapot warm, we place a cosy over the teapot, but even this can only keep the tea warm for a certain time. By warm clothes, we mean the clothes which conduct heat away from the body less rapidly than "cool" clothes. Notwithstanding that we give off a lot of heat in this way, we keep about the same temperature. In health we never get very cold or very warm. In cold weather, during exercise, we are always giving off a lot of heat, yet the body is warmer than when at rest. This is because we are constantly forming heat; everything we do, every movement we make, generates heat. Even when apparently at rest, many important organs are acting; for example, we are breathing and the heart is beating.

Heat generation in the body.—The heat of the body is formed by the union of the oxygen we inspire with the food materials we eat. Whenever oxygen combines with any other agent, it causes the newly-formed body to become warm, whether it burns with a flame or not. In the burning of a lamp, the oxygen of the air unites with the different elements of which oil is composed. The carbon of the wick and oil form with the oxygen of the air carbonic acid gas, and the hydrogen unites also with the oxygen to form water. In this case the oxygen unites so quickly with other bodies that it burns into a flame. There is abundance of carbon and hydrogen in the human body combined with other things. When the oxygen

of the air comes into contact with them, they join with it, and in doing so, produce heat. But they do not do it so fast as in the case of the lamp; no flame is produced; it is a slow process of oxidation or combustion. The heat thus created is just sufficient to keep us in health. Thus, the formation of heat is going on in all parts of the body. The faster we move the more burning goes on.

In warm climates the skin and liver are specially active The abdominal organs are more irritable and are more readily affected by external influences. The functions of the digestive system are impaired. Sudden alterations of temperature are often injurious. A sudden change from cold to heat may induce diarrhœa or other intestinal troubles. A sudden change from heat to cold is liable to lead to chills, congestion of intestinal organs especially of the liver. The European should always be careful to avoid chills. This is specially important in the evening after exercise. The diurnal oscillations of the thermometer in India may be very great, a difference of 80° F. between the maximum and minimum, though very exceptional, has actually been recorded in Quetta. The European has also to protect himself from malarial infection to which, on first arrival, he is specially liable, if he comes to the country during the malaria season.

Damp and wet clothes should not be worn longer than necessary. If the clothes have been wetted, we should keep moving about actively until they can be changed, or have dried on the body. If possible after a wetting the wet clothes should be removed, the body rubbed down thoroughly with a rough towel, and warm dry clothes put on; wet boots and socks should be replaced by dry ones as soon as possible. Damp moist clothes should always be aired and sun-dried before use again. During the rainy season the night clothes should always be dried before being put on.

The best outer garments are those that are light in weight and of a cream, grey or khaki colour, fit loosely and are washable. The twilled cloth now so generally used for *mufti* suits is excellent. Nothing can, however, be said against the khaki drill used by our soldiers in India.

The best form of night suit consists of a mixture of wool and cotton (Ceylon cloth), fine flannel, or a mixture of silk and wool. Any one of these textures will absorb moisture, help to maintain a uniform temperature and to prevent chills. These precautions are particularly necessary when sleeping under a punkah or electric fan, or in the neighbourhood of a working thermantidote, in which case we should always make certain that we are properly covered before going to sleep. Personally, I believe the short jacket worn with the pyjama suit should be discarded as it rucks up at night and leaves the abdomen exposed. It should be replaced by a shirt which should be tucked inside the trousers.

Considering that we pass about one-third of our life-time in sleep, it is important that we should be comfortable when asleep. A damp floor or ground and damp walls predispose to malarial fevers, dysentery, rheumatism, and other diseases. Bedding and blankets should be kept clean, and when possible, exposed to the air and sun every morning, after use, to purify them, as some of the waste matters of the body adhere to them during the night.

If not too cold, the doors and windows of barrack-rooms, and the doors of tents should be kept open at night. Sleeping in a close room or tent is bad for health; it prevents proper rest, and it causes us to get up weary and unrefreshed, instead of rested and vigorous.

The softest and warmest beds are not the most wholesome. Such beds are relaxing and debilitating through the excessive heat they maintain around the body during sleep. This demands the use of warmer clothing during the day with its further enfeebling effect. Such beds create an undesirable "softness" of the constitution, a great sensitiveness to every breath of cold air, or fall of atmospheric temperature. Probably one of the best mattresses is that stuffed with thoroughly clean horse-hair or cocca-nut fibre; straw may also be used for this purpose. By those accustomed to soft beds the hair bed will at first be found hard and uncomfortable, but a man who finds a soft bed a necessity is in a somewhat poor physical state, and the sooner he quits that state the better. The bed clothes should be as light as is compatible with comfort; whilst there should not be any sensation of chillness, there should be one of comfort. All superfluity of bed clothes should be avoided. During sleep the surface of the body should be protected from variations in the atmospheric temperature, for in sleep all the vital processes are carried on less energetically than when awake, therefore less heat is produced, but the circulation in the skin (which is regulated by one of the organic parts of the nervous system called the vaso-motor centre) is active, whilst the air temperature is getting lower as the night advances, hence radiation, conduction, and evaporation, are all in operation. We are losing heat rapidly in sleep, and are unconscious of sudden changes of air temperature that might arise. Chills are specially liable to occur at night if the body is perspiring. Hence the advisability of having on a pyjama suit and using a flannel "cholera belt" or *kammerbund*, and of having a light flannel blanket over our bodies, and all these even in the warmest weather.

We should not sleep with the head and face covered with the bed clothes. This filthy habit necessitates the breathing of the same air over and over again. If the air is damp we should not sleep out at night. Damp air predisposes to many diseases, but chiefly to malarial fevers, dysentery, and rheumatism.

In the absence of a bedstead or charpoy, if obliged to sleep on the ground, we should use some straw, or at least a waterproof sheet. It is necessary to remember that we require as much bedding beneath as we do over us in cold weather.

Mosquito curtains are very useful for warding off mosquitoes and other insects; they also prevent chills by filtering the dew of the air, and thereby lessen the chances of chill; they catch the moisture of the air which so readily produces cold or chills.

The mosquito net.—The mosquito net should be large and have a fine mesh. In airy places where sandflies are troublesome muslin may be used instead of mosquito netting. It is, however, somewhat oppressive within a muslin curtain in a still air. The mosquito net should not be let down trailing on the ground, but be tucked under the mattress. It should be let down and fixed under the mattress before the sun goes down, that is, before mosquitoes come out from their hiding places—this ensures their not being enclosed within the net. Unless the bed is unusually broad, the lower foot of the net should have a double layer of some cotton material to prevent mosquitoes getting at parts of the body that may come into contact with it.

Washing of clothes.—The manner in which the clothes of our troops are washed by *dhobies* is a matter of importance. In the case of European troops this is now almost universally conducted under regimental supervision. In the case of Native troops the *dhobies'* work still calls for reforms, and it would be well if commanding officers and medical officers in all regiments would take up the matter seriously so as to ensure that not only is clean water used and proper methods adopted, but that the clothes at no stage of the cleaning process run the risk of being infected. One has frequently during the last few years watched the process of washing the clothes of Native troops being conducted in stagnant dirty pools, which in some cases were not 200 yards from the regimental lines. Fortunately in India the powerful effects of the sun on disease-germs considerably reduces the risks. An innovation one would like to insist on is the use of "clothes lines" or ropes on which to suspend the clothes while drying instead of spreading them on the ground. It is very desirable that proper laundries be established in all cantonments.

The clothes of officers might readily be washed in the compound by the arrangement of a small washing *ghat* close to the ordinary house well. All that is needed is an ordinary brick or masonry platform 6 feet square, connected by a channel with the well, and enclosed with walls about a foot high, the whole being lined with cement. A short length of metal pipe, capable of being closed with a wooden pin or screw plug should be built into the wall at the lowest level of the platform, so as to allow the dirty water to be drained off. A piece of smoothly-worked plank, about 4 feet by 2 feet with rounded corrugations athwart it, formed like corrugated zinc sheet on a smaller scale, is all the additional apparatus required. These simple appliances would be found more frequently within compounds than they are if officers in general had any idea of the filthy conditions under which their clothing is commonly washed.*

A great deal too much starch is used in the underclothes and linen of Europeans by *dhobies* in this country. Starching removes one of the most useful properties of clothes—that of porosity, the starch fills up the meshes between the fibres of the cloth, and leaves a more or less impermeable water-proof surface. Clothes, especially woollen and warm clothes, take up the bacteria of infectious diseases and carry them about. Hence clothes exposed to this possibility should be thoroughly disinfected.

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* Lt.-Col. G. M. Giles, I.M.S., *Climate and Health in Hot Countries*, p. 25.

D.—Clothing and Equipment in the Field.

Soldier's present-day field kit—its suitability.—The clothing of the soldier in the field, it is scarcely necessary to state, forms one of the most important factors to which both the combatant and the military medical officer can turn their attention Experience in our Frontier campaigns in India has brought us to a fair state of perfection in this respect. The regulation field kit of the present day is as rational and complete as can be reasonably expected, if we take into consideration the varying conditions of Indian Frontier warfare. It is the penultimate outcome of experience and its attributes depend upon its durability, permeability and the quality it possesses as regards its conduction and absorption of heat.

Scale of clothing on field service.—The ordinary field service scale of clothing and bedding for the N.-C. Os. and men of European infantry regiments is :—

Carried on person.

Aluminium identity disc ...	1
Arms and accoutrements, set ...	1
Bandolier, filled	1
Boots, ankle, pair	1
Braces, pair	1
Coat, warm, British (winter only)	1
Emergency ration	1
First field dressing packet ...	1
Flannel shirt	1
Haversack with knife and fork ..	1
Helmet, khaki	1
Jersey (winter only)	1
Khaki frock	1
,, trousers, pair	1
Clasp knife with lanyard ...	1
Mess tin	1
Mittens, pair (winter only) ...	1
Putties, pair	1
Socks, woollen, pair ...	1
Water-bottle	1
Back pad	1
Sun spectacles	1
Sunshade for helmet	1

Carried on 1st line of transport.

	lb.	oz.
Blanket, barrack	4	12
Coat, warm, British (summer only).	4	12

Carried on 2nd line transport.

	lb.	oz.
Balaclava cap (winter only)	0	6¼
Blanket, barrack ...	4	12
Boots ankle, with spare laces, pair	3	9
Field cap	0	6
Flannel belt	0	5½
,, shirt	1	2¾
Hair brush	0	3
Holdall (with comb, razor, shaving brush and spoon)	0	11¼
Housewife	0	4
Khaki frock	2	12
,, trousers	2	12
Log line for packing kits ...	0	4
Small-book	0	3
Socks, woollen, pairs 2 ...	0	9
Soap, piece of	0	2
Towel	0	8
Tin of dubbing	0	4
Waterproof sheet ...	3	8
Total weight allowed all seasons ...	21	

In Frontier campaigns in the winter a third blanket should be issued to all troops.

Practically the same scale is allowed to Native infantry troops.

The equipment for followers and private servants consists of:—

Carried on person.

Aluminium identity disc	...	1
Leather belt	...	1
Blanket, country (winter only)	...	1
Blouse, khaki	...	1
Coat, warm, followers (winter only)		1
Pyjamas, warm (winter only), pair		1
Pagri	...	1
Putties ... pair	...	1
Rations, 1 day's	...	1
Shoes or boots (country made) pair		1
Underclothing, suit of.		
Water-bottle, zinc.		

Carried on 1st line of transport.

Blanket, country (only for ward servants, *bhistis*, *pakhalis*, and A. B. C. bearers, in winter).

Carried on 2nd line transport.

	lbs.	oz.
Blanket country ...	4	0
Cooking-pots ...	2	0
Spare clothing ...	4	0
Waterproof sheet ...	3	8
Total ...	13	8

Special articles for different campaigns.—For campaigns conducted in cold climates, special articles of kit will be authorised, such as goat or sheep-skin coats *(poshteens)*, warm Balaclava caps, gloves or mittens, Gilgit boots, extra blankets, etc., according to circumstances.

Scale in Tibet.—The above scale may be modified in campaigns to suit the climate, time of the year, or meet special local conditions: *e.g.*, in the Tibet Mission both British and Native troops, as well as followers, received:—

Summer.—

Blankets, black ...	2
Coat, warm ...	1
Mittens ...	1 pair
Balaclava cap ...	1
Waterproof sheet ...	1

Winter.—The special scale in Tibet during the winter months, for all troops and followers consisted of:—

Poshteen ...	1
Razai (quilt) ...	1
Woollen gloves ...	1 pair
Fur-lined gloves ...	1 pair
Lamb's wool vest ...	1
Overalls ...	1 pair
Comforter ...	1
Gilgit boots ...	1 pair
Goggles ...	1 pair

One extra blanket and one pair of woollen drawers were also issued.

Transport allowance for followers' baggage deficient.—Before concluding this subject one would remark that the baggage allowance of followers—$13\frac{1}{2}$lbs.—is scarcely sufficient when fighting in cold countries. He is usually given two blankets of 4lbs. each, and a water-proof of $3\frac{1}{2}$lbs. as part of his kit. He has also his cooking-pots and some extra clothing—all these must be carried. A weight of 15lbs. should be given. In certain places such as Burma and the North-Eastern Frontier, the present allowance would be sufficient.

Underclothes.—The ordinary underclothing of the British and Native soldier in India consists of shirts and socks; the British soldier has also a flannel belt.

Two flannel shirts always required.—Two flannel shirts form part of every soldier's kit on field service; they should reach well below the hips, preferably to the middle of the thighs. The typical shirt of this kind is the British soldier's grey flannel one. There is much variation in the make and quality of the so-called flannel shirt in our Native Army—from being almost entirely cotton and reaching barely to the hips, to pure flannel of proper size and make. The nearer it is to pure flannel the better it serves to protect men from chills by reason of its being a non-conductor of heat, and its high absorptive quality as regards perspiration.

Fabric of shirt.—The British soldier's shirt, made from a mixture of cotton and wool, is light and cheaper than pure wool, is more durable, and does not shrink in washing. It should not, however, consist of more than 30 per cent of cotton. Grey is the best colour for the soldier's shirt, khaki next. In all cases the collar and wrist bands of the woollen shirt should be made of linen or cotton material to obviate the effects of shrinking and consequent tightness.

The ordinary grey flannel shirt irritates the skin of some men, and may produce prickly heat in the hot weather. It is advisable that it be supplemented in the hot weather by the use of one of the Indian gauze undervests or banians. The shirt worn during the day should not be worn at night. It is very desirable that all soldiers provide themselves with pyjama suits for night wear—two suits are required, one for use while the other is being washed.

Socks.—The men's socks require almost as much attention as the boots, and one's experience is that this is a matter greatly neglected by regimental officers. The grey sock made of worsted is most excellent to march in. It should be shrunk before issue. The great complaint is that the number prescribed for field service is too small. In marching there is excessive perspiration in the feet which cakes with the dust and dirt generally, and predisposes to sore feet, and it is probable that many cases of sore feet arise in this way. A good sock, fitting the foot, free from holes, and kept clean, is a great protective against sore feet. Socks should be frequently washed.

All soldiers should have at least four pairs of socks. This allows of two pairs in use and two with the *dhobie*. Socks should be fitted on with the same care as boots—if too large they ruck and crease, and cause blisters, if too small they rapidly become holy. Dirty socks should be a soldier's abomination; they stink, and are crowded with germs which rapidly invade the smallest abrasions or blisters of the feet.

For ordinary use in cantonments in peace times during the hot weather on the plains merino socks might replace the worsted ones.

In some European Armies bandages are worn around the feet and legs instead of socks. Their chief advantage is that "they can be easily cleaned and replaced when worn out."

The cholera belt—its uses.—At the risk of being considered old-fashioned one would strongly recommend the so-called *cholera belt* as an article of kit indispensable to every soldier in the field. As you know, it consists of a double layer of flannel encircling the girth; it should reach from below the nipples down to the hips. It saves the soldier from a host of ailments—it costs about 8 annas, weighs only five or six ounces, lasts him throughout a long campaign, and can be washed and dried in an hour. Its special virtue rests in the fact that it maintains an equilibrium in the circulation around the organs most liable to be affected by the vicissitudes of temperature common in cantonments and in most of our Frontier campaigns. Its use should be made compulsory. Many British officers consider it a fad, and the British soldier, very often in the hot weather, discards it. One would at least emphasise the necessity for its use in campaigns. In the absence of cholera belts, the *putties* should be worn around the waist. The cholera belt should only be worn at night. A cholera belt is also made of knitted woollen material or Jaeger wool in the form of a single complete band for the waist. This form is undesirable as it rucks up. It is sometimes advised that the cholera belt material be sown into the upper part of the night pyjamas to keep it in position. The ordinary flannel belt provided with buttons and botton holes or a double set of tapes does not ruck up.

Drawers.—Drawers would form an acquisition to the European soldier's kit from reasons of cleanliness. and of warmth to the lower part of the abdomen. All soldiers should have two pairs of drawers; they are specially necessary for cleanliness and to prevent chills in the abdomen. Without drawers the "shorts" soon become filthy inside, laden with dust which mixes with the sweat and irritates.

Trousers.—The trousers and "shorts" should always be loose and comfortable over the hips, buttocks and thighs and be kept up by braces. Belts should never be worn to keep up the trousers; they compress the abdomen, interfere with free respiration and are said to favour constipation.

One might here remark that all clothes on field service should fit fairly loosely so as to permit of free movement of all parts of the body, otherwise mechanical energy is unnecessarily expended.

"Shorts" on field service.—The question of the use of "shorts" often arises, and opinions as to their merits, even amongst experienced medical officers, vary. They are most popular amongst European troops, and Gurkha and other Native soldiers, and they are undoubtedly most comfortable on long marches. One has personally not met with any special discomfort or ailments arising from their use by men who have worn them in both hot and cold weather. It is probable that when marching in our N.-W. Frontier during the winter, serge "shorts"

would be preferable to drill ones, and combined with half-hose knee gauntlets above the putties in very cold weather, are quite comfortable. It is desirable that there should always be a loose under-drawer worn with "shorts."

Khaki jacket.—The khaki service jacket should be quite loose and never worn so as to fit tight and smart-looking. In the case of officers, with a soft collar and a necktie, it approaches the acme of hygienic and æsthetic requirements. A loose coat protects the body from chill better than a closely fitting one, as it has between it and the skin a layer of non-conducting air. It also permits of the lungs expanding freely, and the heart to work without any external pressure. When the khaki drill coat is used, it is necessary to insist on men wearing a flannel shirt beneath it; this shirt is a great protection from chilling of the surface. It is only very exceptionally that khaki serge is required for the coat instead of khaki drill. The coat warm British is usually sufficient to tide over the influence of coldness of the air, and prevent chill; it is always at hand and can be used when necessary.

Braces.—*Braces* are certainly preferable to belts around the waist; they form a better means of support and do not compress any part. Tight belts are said to predispose to hernia.

The great-coat.—The *great-coats* of our British and Native Troops are almost invariably of excellent quality as regards the cloth. The chief defects one notices is that they are not made long enough and they are too heavy. The great-coat, which in different regiments of infantry weighs from about $4\frac{1}{2}$ to $6\frac{1}{2}$ pounds, can absorb an astonishing amount of rain, and when saturated is very heavy. Many authorities consider that it would be preferable were a "waterproofed" great-coat of lighter weight to be introduced. This is now done in some armies. There are various cheap methods and compositions for effecting this waterproofing

A good waterproofing material is made from 3 per cent. lanolin in benzoin. The material to be waterproofed is steeped in this solution, the article thoroughly wrung out and the excess of the solution allowed to evaporate rapidly in the air. About four pints of solution are required for the entire effects of a soldier. "Clothing impregnated with wool fat (lanolin) may be worn both in rain and sun without ill effects, prevents the rapid evaporation of perspiration, and affords a better protection against rain than fabrics waterproofed with alum preparations or other chemicals, as recommended by some authorities." Clothes infiltrated with wool fat are even more permeable to air than clothing not so treated, and are also less absorbent of watery vapour. Moderate washing has no effects on the waterproofing of fabrics produced by lanolin, so that the effects of the procedure are fairly permanent. It costs about a rupee to waterproof a complete uniform. It waterproofs but prevents the free passage of air and watery vapour. It does not increase weight or alter the appearance, colour, or odour of the garments. It increases the solidity and strength of the fabric. It is cheap and simple in application.

Another waterproofing composition is a weak solution of glue to which while hot add alum in the proportion of 1 ounce to 2 quarts. As soon as the alum is dissolved, and while the solution is hot, brush it well over the surface of the cloth and dry. The addition of two drachms of sulphate of copper improves it. Dipping clothes alternately in a solution of sulphate or acetate of alum and of soap also waterproofs them.

Waterproofs have the disadvantage of keeping the body covered with a layer of perspiration. They should be discarded when no longer required to keep out rain. Several articles of the soldier's kit might be waterproofed with advantage.

Great-coats should not be worn on the march, even when it is raining. They should be dry and ready to put on over the wet clothes. A dry great-coat over wet clothes is better than a wet coat over clothes soaked with perspiration. The great-coat of a soldier is one of his best friends on field service, and should be either with him or readily get-at-able. When hot and perspiring on arriving in camp, especially if in the evening, the great-coat should be worn. Changes of air temperatures are often sudden, especially in the evening; hence the necessity of men always having their great-coats, or "coat warm British" ready to use if required. This is especially necessary in the case of men on sentry duty in the evening and at night.

The waterproof sheet.—On field service the soldier's waterproof sheet is indispensable to protect against rain or moist ground, and even when the soil is dry, it should be used to lie on when not used to form a temporary *tent d'abri.*

Helmets.—The present pattern of helmet worn by our British troops is vastly superior to any previously issued.

Essentials for the head-gear.—The essentials of a good head-gear are:—That it should be light, durable, comfortable, not press unduly on any part, and not fit too closely on the head. It should admit of a limited amount of ventilation, and its shape should not only serve as a protection to the head against sun, but should afford as little resistance to the wind as possible,* whilst it should not interfere with a man's shooting in any way.

The new pattern helmet of the British soldier is by far the best article of the kind yet issued. It is made of bamboo or cork, covered with cotton cloth, and provided with a *pagri.* It at once protects the head and neck from the sun efficiently, weighs about 13 ounces, and permits of the man using his rifle in any position. It has been suggested that it should be lined by orange coloured flannel, and if the present day views as to the effects of the violet and ultra-violet rays of the sun are correct, this appears to be indicated. A recent extensive enquiry, however, carried out on 1,000 soldiers of the U. S. Army in the Philippines appears to indicate that the use of such coloured material increases the heat of the head and adds to discomfort. In the hot weather all European soldiers, when outside, should wear their helmets from sunrise to sunset.

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* MONSON'S *Military Hygiene*, p. 1005.

Up to tho present no material has been found that excels the ordinary *solah* or pith hat. The best shape is that of the Cawnporc Tent Club *topee*, which has the brim straight in front, and sloping everywhere else. This was for a time a very popular hat for European troops on field service. Thc interior of the sun *topee* must be well ventilated. This is effected by having the hat band separated from the hat by bits of cork or pith. If thc pith is thick enough no further cover is required and certainly the use of the thick cotton quilted cover does not add much to its utility but does add considerably to its weight. These *solah topees* are made of strips of solah pasted together and so do not stand rain well, but this may bc obviated by thc use of a thoroughly good waterproof cover instead of the ordinary drill one, or by waterproofing the drill cover. Thick stiffened felt is also good, especially of double with an intervening layer of air between.

Many persons are affected by the direct rays of the sun beating on the spine, especially on its upper part, giving rise to symptoms of dull aching and oppression. This is prevented by the use of a *spine pad* made to cover the spine and consisting of a double fold of khaki with cotton wool between, this being fixed on to the coat by hooks and eyes, or buttons (and therefore detachable) and being somewhat T-shaped.

When the body, head and spine are properly protected the actual heat rays of the sun—solar radiation or red rays—is seldom sufficient in the acclimatised, to be seriously injurious except in those whose heat-regulating mechanism has been damaged by overwork, by excessive indulgence in alcohol, or those who actually have naturally an inordinate susceptibility to the heat rays. Thc effects of the *light rays* of the sun are to be excluded as far as possible.

The light rays aro the blue, violet and ultra-violet actinic light rays of the spectrum.* It is these light rays that are responsible for the production of sun-burn and sun fever, of which latter there are extreme grades. It is supposed that the pigmented skin of the native of the tropics is a natural protection against the actinic rays. The white material such as is usually worn, drill, etc., is almost transparent to the actinic rays of the tropical sun, and it does not protect us from these. The white surface reflects some of the longer red rays, yet thc material is too thin to totally exclude them, and consequently it is by no means as cool as we could wish, when actually in the sun. The reflected white light is excessively annoying (and in course of time injurious both to the eyes of the wearer, and thosc of his neighbours.

It has certainly been shown that the pigmented surface of the native has a strange protective effect against the passage of the injurious actinic rays. Various experiments have shown that probably the most protective colour against the actinic rays of the sun is *khaki*, that a covering of this gives the same kind of protection that the pigment of the skin of the native does. Khaki reflects the long violet rays of the sun almost as well as white cotton does.

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* When white light passes from one medium to another, it is not only bent
out of its course (reflected), but is decomposed iuto several kiuds of lights which are
coloured. This phenomenon is called *dispersion* aud the coloured lights form a
spectrum. White light in passing through a prism is decomposed aud we can dis-
tinguish the colours into which it is broken up ; these are red (the least refracted
of the rays), orange, yellow, green, blue, indigo, violet and ultra-violet (the most
refracted). The ether waves composing a light ray are of different lengths and there
is a particular shade of colour corresponding with each wave length. waves pro-
ducing the sensation of voilet being the shortest which exert an effect on the retina
of the eye, while those producing the sensation of red are the longest. The waves
of different lengths are separated by the prism, and thus we get the spectrum.
The *heat rays* correspond with the red end of the spectrum and outside it, the *light*
rays correspond with the violet end of the spectrum and beyond it (ultra-violet rays).

Putties.—*Putties* support the legs, keep them warm, do not interfere with the movement of the muscles in front or behind the leg, and protect from reptiles and insects ; they are very comfortable to march in. Putties should be carefully adjusted. It is specially necessary to avoid winding them so tightly round the legs as to cramp the action of the muscles or stop the circulation in the superficial vessels. Trained soldiers should teach their younger comrades how to adjust them so as to be comfortable in marching.

Leggings.—In European armies either leggings or long boots are almost universally worn, leggings being very popular with the troops where they are used, as they are easily removed and can be rapidly cleaned. Well-fitting leggings are best for cavalrymen. They should be carefully tried and tested before use on field service. Most of us know the utter discomfort associated with wearing tight leggings.

Boots.—It is impossible to emphasise too much the intimate relationship between well-fitting and well-made boots and the soldier's military efficiency. A pair of boots that prevents a soldier from marching, whilst directly answerable for the man's inefficiency, the real responsibility is in the original issue of the boots.

It is on record that 30,000 German soldiers were unfit for duty during the first few weeks of the Franco-German War on account of injuries of the feet due to badly fitting boots that had become hardened by long keeping in the supplying stores.

Footsoreness may arise from initial defects in the structure of the boots, or from boots being allowed to get hard, or to their being worn out and it being impossible to repair them.

The nature and shape of the boots and the quality of the leather are important. A boot should be considered as natural when its greatest length is in a line through the middle of the heel and middle of the great toe, and its greatest breadth through the bases of the five toes (metatarsal bones), this latter giving an oblique line in relation to the axis of the foot. The heel should be strong, resistant, broad, not more than one inch in height, and long enough to support the whole heel.

It has often been a question whether laced ankle boots or long boots are best—the former are cheaper, easier to put on, aud easier to dry, whilst long boots protect better against damp, cold and injuries. The question however does not arise in our infantry soldiers in India who have all the advantages of laced boots and *putties*.

Regulation boot.—The British soldier's boots weigh about 40 ounces, and are made in 32 sizes. The sole is wide, and the heel low and broad. The leather has to be of a specified quality. There must be eight stitches per inch for the upper leather, and the thread must be of a certain strength and well waxed. Its great defect is the hardness of the leather and rough finish. The regulation boot of the

British soldier should be quite sufficient for ordinary feet, but as we know, there are trifling peculiarities, such as a small ankle, high instep, unusually broad and short or elongated and narrow foot, to which the regulation boot does not always accommodate itself. The recruit is still a growing lad, and in the first year, especially under his training, his feet are likely to get larger. Hence the two pairs of boots issued to him may be too small later on. When once moulded to the foot by wear, the regulation boot is excellent. The Russian Army uses soft leather and appreciate it greatly ; footsoreness is said to be unknown.

In fitting for boots they should be tried on over a thick pair of worsted socks, and it is advisable to have them a size larger than required, which allows for the swelling of the extremities associated with hot weather and for expansion of the feet in marching. We should avoid on the other hand boots that are too loose as they increase friction. The fit should be quite easy and comfortable.

It is specially necessary to avoid any tightness over the instep and across the toes. The sole should be pliable; hard, dry, stiff soles are very fatiguing.

With a little trouble in selection from the 32 sizes it is possible to give 99 per cent. of the men properly-fitting boots. It depends on the care with which officers carry out the duty of supervising the fitting. The mere placing of a section of men with a large box full of boots and telling them to fit themselves is not sufficient. This one has seen done.

The sole should be supple, since if it is too thick flexibility is lacking; if too thin, protection is insufficient and the boot lacks solidity. The insole should be slightly concave to receive the heel and ball of the foot. The uppers of army boots are inclined to be too thick and stiff, and sometimes exert undue pressure on the inner side of the ankle.

In the ideal boot the sole should conform in shape to the natural foot, which is a long curve on the outside, while the inner side approaches a straight line. Ample space for the little toe should always be provided. The toe of the boot should be slightly rounded, the foot being towards the curved aspect rather than the centre, but no great breadth is necessary at the middle of the foot as this does not spread. The sole should be a little wider than the upper (about $\frac{1}{8}''$), but if it projects too far, it tends to accumulate mud.

Briefly then, every man's boots should fit well and be soft. The sole should be sufficiently thick, and yet not too thick, heavy and stiff to prevent the foot bending at each step. It should be easy to dry, and it should be easily re-soled. It should be comfortable to walk in, and it should open well so as to be readily dried inside when it has got wet.

Excellent boots are now made on a large scale by many factories in India out of indigenous leather.

New boots should be worn for some weeks before taking them into use on field service.

Master boot-maker for regiments.—It has been suggested that a skilled master boot-maker should be attached to each infantry regiment, a man who is a finished artisan at his trade, to effect alterations in the regulation boots in particular cases. A number of cases occur of inflamed hard or soft corns from friction of ill-fitting boots, and in the case of soft corns also from dirt between the toes aggravated by pressure. These can all be prevented.

For field service the boot should be made impermeable to wet. The late Prof. PARKES recommended the following recipe to effect this:—Shoemaker's dubbing, ½ pound, linseed oil ½ pint, solution of India-rubber ½ pint. Dissolve by gentle heat and rub on the boots. This will last for five or six months.

All boots kept in the quarter-master's stores should be rubbed with dubbing at least once every two months.

Dubbing is preferable to blacking for softening boots—it makes the leather softer and with it they last longer. Country castor oil, which is obtainable everywhere in India, is an excellent material to soften boots, especially the uppers. It is very cheap. The French use 3 parts mutton fat and 7 parts neat's foot oil.

Wet boots should never be exposed to a fire to dry—this tends to destroy the leather and hardens it, which then causes rubbing when worn. If heat is used care should be taken not to scorch the leather. It is preferable to use a liberal supply of dubbing or grease while the boots are still wet, this will keep them supple.

Canvas shoes are very comfortable after a day's march, and although only a luxury should be worn when convenient to do so. The *khaki* canvas shoe made by *mochis*, without lining, is one of the most comfortable forms of foot-gear when men are not on duty, though not very durable.

The full inspection of all boots and socks is urgently called for before a campaign. All socks with holes, or rough darnings, or worn threadbare should be replaced and condemned. The causes which should lead to condemnation and replacement of boots are sufficiently obvious and call for no remarks.

Stock of boric acid powder in quarter-master's stores.—It is desirable that every quarter-master should have in store (or in the canteen) a supply of powdered boracic acid to dust between the toes and over any part that is rubbed.

The water-bottle—Essentials of a good water-bottle.—The *water-bottle* of the soldier for field service should possess the following feature:—

(1) It should be sufficiently large, not less than 1½ (and preferably 2) pints.

(2) It should be get-at-able for purposes of sterilisation. The best form of sterilisation is the use of boiling water, or actual fire. To effect the former it should have a removable top.

(3) Some form of light metal is desirable, aluminium being best.

(4) It should have a cover of some non-conducting material such as felt, and this should be easy of removal to get at the bottle to clean it, when necessary.

(5) It should be of suitable shape so as to be easily carried.

It has recently been shown by a series of observations on water-bottles actually used on manœuvres that they may become breeding grounds for disease-germs. It is difficult to inspect the existing patterns of water-bottles satisfactorily. The mouthpiece of most water-bottles is too large, and serves to collect microbes and dirt. It has been suggested that it be provided with a screw stopper. The felt covers of the present water-bottles wear out very quickly. It should always be borne in mind that it is dangerous to store filtered or sterilised water in unclean water-bottles, or to mix it with unfiltered water. Water-bottles should be kept clean by scalding in boiling water at least twice a week. Water-bottles when not in use should be kept empty.

The present pattern of water-bottle is certainly not a good one, for if it is once infected with typhoid fever or other germs of water-borne disease it may remain infected after even several washings.

Chief points connected with equipment.—The question of equipment presents several points for consideration to the military medical officer, especially in regard to the distribution, adjustment and balance of the actual weight of equipment carried by the soldier, the effects of compression of the heart, lungs and arms due to belts and straps, and the general effects of the total weight carried on the man's physique and strength. The two former points need not be here considered as the weight actually carried now is fairly well distributed and the soldier marches with comparative comfort. Regarding the actual weight carried by the soldier on field service, there is a general agreement that it should be reduced to the smallest minimum compatible with the best fighting efficiency.

The articles of the personal kit and equipment of the soldier of the Home Army is laid down in Army Order No. 71 of 1904. It includes 100 rounds of ammunition, clasp knife, and all other articles, including 1 pair of drawers, weighing in all 50 lbs. 7½ oz. This load should be thoroughly well balanced and not press the body backwards or forwards. If not balanced it leads to straining and fatigue.

The load carried by the soldier requires to be arranged with the greatest care and thoughtfulness, so that the weights do not detract

from the man's efficiency, or injure his health. The chief points to attend to are that the weights should be adjusted so that when carried they fall as near the centre of gravity as possible, and not outside it. "In the upright position the centre of gravity is between the pelvis and the centre of the body, usually midway between the navel and the pubis, but varying with the position of the body; a line prolonged from this centre of gravity to the ground passes through the centre of the ankle." Hence we endeavour to keep the weights carried by men near the centre of gravity. The old mode of carrying the soldier's great-coat on the back of the knapsack was a bad one, as it put the weight at the greatest possible distance from the centre of gravity.

These principles are to a great extent utilised in the bandolier equipment now in use, and it is light and simple. The ammunition is contained in four pouches in the bandolier. The mess tin is carried either on top of the great-coat or under it when this is carried on the shoulders, or it may be fastened to the waistbelt; in each case it can be detached without interfering with the rest of the equipment.

The equipment carried by the infantry soldier in the Home Army at present consists of:—

	lb.	oz.
Rifle, short, with sling	8	3½
Sword-bayonet, with scabbard	1	4¾
Belt, waist, with four cartridge pouches	1	9
Frog for bayonet	0	4¾
Bandolier	1	2
Ammunition (100 rounds)	6	14
Haversack, containing bread or biscuit, emergency ration, fork, spoon, and tooth-brush	2	14½
Mess-tin and cover containing some ration	2	3¼
Water-bottle, filled, and strap	3	12
Tin of mineral jelly, pull through and cover	0	8½
Great-coat, with comforter and a pair of socks	6	6
Head-dress	1	2¾
Jacket, with first field dressing and description card ...	2	8½
Trousers (or kilt and apron, 4 lb. 5 oz.)	2	1
Jersey or cardigan	1	5
Braces	0	4½
Shirt, flannel	1	1½
Belt, woollen, and socks	0	8¾
Boots, ankle	3	14
Puttees or gaiters	0	14½
Clasp-knife and lanyard	0	8
Drawers, one pair	1	0½
Total ...	50	7¼

The most objectionable part of the present equipment is the bandolier, which, when loaded with ammunition, presses on the man's chest.

The *new experimental equipment* (which has recently been subjected to an extended trial), or some modification of it, will probably be introduced at no remote date. It is simple in construction, light, durable, has no straps crossing the chest, and can be rapidly put on and

off. It allows of the waistbelt being unfastened on the march, and even when taken off will remain completely assembled. It permits of a reasonable quantity of spare kit being carried on the march, and, if necessary, allows of the kit-carrying portion being discarded, leaving the wearer with his fighting essentials only. The main defect of this equipment is that it is very hot. Its weight alone is 4 lbs. 13 oz., and, with a maximum ammunition capacity of 150 rounds, represents a total load, without spare kit and entrenching tools, of over 15 lbs.

"The committee draw the following conclusions from their experiments and observations on the new experimental equipment:—

"The new equipment is superior to the old in the following respects. The weight of the sack behind is so well balanced by the weight of the ammunition in front that marching can be performed with the belt, jacket and shirt widely open. There are no straps constricting the chest. The load is borne chiefly by the shoulders. The facility and

Fig. 59.—New Experimental Equipment. Front View.

Fig. 60.—New Experimental Equipment. Rear View.

quickness with which the new equipment, in full marching order, can be taken off and put on enable the soldier to obtain full benefit from any halt of a definite duration. The close application of the sack to the back of the soldier is a disadvantage which could be easily overcome.

"The full equipment is comfortable, and the weight is not excessive for the man who has been progressively trained in marching with a load.

"The clothing of the soldier is good and suitable for his work. The field service cap gives sufficient protection to the trained man who has become accustomed to exposure to the heat and glare of the sun, but for most members of the Territorial Army a light slouch hat would be more suitable.

"The committee wish to lay stress on their former recommendation—'That it be an instruction to officers commanding that the order shall be given to men on the march in warm weather to open the jacket and shirt,' for they have evidence that it is not sufficient to leave the initiative to the company commanders or to the men themselves."

The recent committee on equipment at Home advise that the following additional essential articles of spare kit should be carried :—Bootlaces, housewife, towel and soap, pay-book, and if possible an extra flannel shirt. This makes a total additional weight of 1 lb., or 2 lbs. $1\frac{1}{2}$ oz. if he carries the shirt, in which case the total weight will be 52 lbs. $8\frac{3}{4}$ ozs. They consider the canvas shoes now carried a luxury.

The *rucksack* equipment has also been tried. The principle upon which it is based is to give each man a light and useful container for all his authorised field kit, other than his arms, ammunition, and water-bottle. If considered necessary, as in an impending action, the rucksack and its contents can be discarded at once, only such articles as arms, ammunition and water-bottle being carried. "The rucksack as issued was of the Alpine type, and consisted of a rectangular bag of canvas, the approximate dimensions of which are 17″ × 17″. The mouth of the bag, which is situated at the top, is closed by a running cord, and two pockets are externally attached to the rear face. The lower and larger one is intended to hold the mess tin, and the upper one the grease tin and any other small articles. The main portion of the bag carries the great-coat, folded or rolled, also any spare or extra ammunition. The rucksack is carried by means of two web straps joined to the top and bottom corners of the sack. The arms are passed through these straps and the latter rest on the shoulders. When it is remembered how necessary it is for an infantry soldier to have an equipment giving expansive carrying power, either for food, ammunition or clothing, the utility of this form of valise cannot be called in question. The advantages of the rucksack are that it can be taken off or put on in a few seconds; further, when marching or when halted, the coat can be opened from top to bottom without disturbing the equipment. There is nothing hanging about the man to impede his movements, as the load is compact and out of the way. The wearer's arms are free, and his shoulders are not tied down to his belt by straps as is the case in the ordinary form of equipment. The sack can be

carried easily over the great-coat and itself has a carrying capacity much in excess of any other article of the kind. In packing the rucksack it is important to keep the weight at the bottom. Everything should be flattened down well; the better the rucksack is packed the better it rides. The carrying straps should be kept long so as to allow the weight to rest, so to speak, on the buttocks"*. It is possible that some form of rucksack equipment will be used in the future by our European troops, but whether it will be introduced it is impossible to say at present as the new experimental equipment (Figs. 60 and 61) possesses most of its advantages; the rucksack equipment, however, has many advantages for the Native Army.

Minimum weight to be carried by the soldier.—A considerable amount of work has been done in Continental armies in recent years in connection with the soldier's equipment on field service, the general object being to lighten the weight he has to carry as much as possible. These weights vary very considerably in different armies. In 1893 the infantry soldier in different armies carried:—

Italy	... $72\frac{1}{2}$ lbs.	Russia	... 65 lbs.
Germany	... $71\frac{1}{2}$,,	Austria	... $64\frac{1}{5}$,,
Switzerland	... $66\frac{4}{5}$,,	England	... 63 ,,
France	... 65 ,,	Belgium	... $62\frac{1}{2}$,,

Changes in the equipment in the French infantry.—The dark blue overcoat and the red trousers are retained as a service issue (it is understood that the latter are considered useful as an indication for the artillery, so that they may not fire into their own infantry comrades). The great-coat is, however to be made of lighter material than the present coat, with a falling collar and cape, and bronze buttons. In place of epaulettes, blue shoulder straps with a small roll of cloth at the outer end are to be worn. This latter addition is intended to prevent the rifle or rifle-sling, as the case may be, slipping off the shoulder on the march (the Austrians have a similar contrivance, but on the right shoulder only). In barracks, but only exceptionally on the march, the soldier is to wear a single-button blouse (*vareuse, litewka*), which on manœuvres will be provided with a stand and fall collar. No change is intended as regards head and foot gear. The latter consists of lace boots and leather gaiters with light camp shoes. All leather straps are to be of the natural colour (the present straps are black). The knapsack is to be brown and soft like a rucksack. It lies when carried somewhat low on the back, and has two straps through which the arms are passed. On the rucksack is carried the mess tin. The haversack and water-bottle no longer hang on straps which cross the chest and interfere with the breathing, but are so arranged that the weight bears directly on the shoulders. All metal parts are of aluminium. The weight of the side arm and entrenching tool bears partly

* Colonel R. H. FIRTH, R.A.M.C., *Military Hygiene*, p. 247.

on the belt, and partly on the great-coat, by means of special straps. The soldier also carries in his belt three flat cartridge pouches, two in front and one behind, holding in all eighty-eight cartridges (the number carried in the present equipment is one hundred and twenty, in three pouches similarly arranged). The remainder of the ammunition is to be carried in the company ammunition cart. In the rucksack only one shirt, one soft cap, one set of eating utensils, an iron ration, six biscuits, and the camp shoes are to be carried. In addition, one ration bag will be carried for every eight men, and a water bucket (*Wassereimer*) for every half section. The whole knapsack only weighs about six and a half pounds. All necessaries except the above-mentioned articles, including the blouse, will be made into a bundle *(ballot individuel)* and carried in the company baggage-cart in the first line transport. The entire load carried by the infantry private will in future be 20 kilogrammes, as compared with 26·7 kilogrammes carried by the German soldier. The following table gives the comparative weights of the present and the proposed knapsack and contents :—

	Present.	Proposed.
Knapsack ...	3 lbs. 8½ oz.	1 lb. 4 oz.
Shirt	9 oz.	11⅓ oz.
Cap	1½ oz.	3⅓ oz.
Shoes	2 lbs. 2 oz.	2 lbs. 4 oz.
Iron ration ...	4 lbs. 13 oz.	2 lbs.
Mess tin	13 oz.	13 oz.

In addition, in the present equipment, other articles are carried in the knapsack, bringing the total weight up to 7,804 grammes so that the total saving in this direction is 4,804 grammes, say 10½ lbs. The new great-coat weighs only 3 lbs. 2 oz. as compared with 7 lbs. 8 oz. in the case of the present pattern, whilst the weight of the water-bottle when filled is reduced from 2 lbs. 15 oz. to 2 lbs. 7 oz. The weight of these, keeping the present size and shape, but substituting aluminium for tin, could be reduced by about one-third. It is evident that apart from this the alterations in the weight of the knapsack and its contents, and the lightening of the great-coat, signify a total reduction of weight of about 12 lbs., a very sensible improvement. The present equipment, including arms, ammunition, entrenching tool and shelter tent, weighs from 55½ to 62½ lbs. The proposed equipment will only weigh 44 lbs. In view of the work of ZUNTZ, which seems to show that any weight in excess of one-third of the body weight (that is 45 lbs. for a 10-stone man) seriously penalises, in the racing sense, the carrier, these reductions can only deserve the strongest approval from the physiological point of view. Whether the reduction of ammunition will meet with equal approval from tacticians, or the reductions of comforts prove to the satisfaction of sanitarians, is another matter which merits serious consideraton. There have been alterations also in the composition

and packing of the iron ration. Instead of carrying two days' ration, one only is now carried by the man, the other being placed in the transport. The sugar and coffee are increased at the expense of the rice and dry vegetable issue (the old ration contained 30 grammes of rice and the same amount of dried vegetables, with 21 grammes of sugar and 16 of coffee). Each man now carries a small tin of preserved meat; previously one in four carried a large tin weighing 1 kilogramme (2·2 lbs.) and the daily allowance has been raised from $8\frac{1}{3}$ oz. to 10 oz.

A great advance was made in our Army when arrangements were introduced for having the valise carried regimentally. In all our recent manœuvres and campaigns this has been done, and with the aid of our transport cadres, will continue to be done in future campaigns.

The lighter load carried by the Japanese, as contrasted with that of the Russians, was no inconsiderable factor in the late war. It is said that in the retreat from Liao-Yang, the heavy mud roads with the excessive heat of July 1904, together with the heavy equipment and cloth uniform, told greatly against the Russian troops. It makes a serious difference to a man during a long march, or in a heavy day's fighting, whether he has to carry 60 lbs. or 40 lbs. The actual weight carried in fighting will, of course, vary; *e.g.*, at the end of a day the man will have eaten his ration, emptied his water-bottle and fired his rounds, and he may or may not for the time be carrying his great-coat. The great point aimed at is to reduce the weight actually carried by the man as much as possible, and the means by which this is to be effected will doubtless continue to receive the attention it deserves. As you know, the lighter the equipment the greater the mobility of the force.

Principles regarding the position and adjustment of weights carried.—Weights are best borne when the following general principles are attended to:—

1. They must lie as near the centre of gravity as possible. In the upright position the centre of gravity is between the pelvis and the centre of the body, usually between the navel and pelvis, but varying, of course, with the position of the body; a line prolonged to the ground passes through the astragalus in front of the os calcis.* Hence weights carried on the head or top of the shoulders, or which can be thrown towards the centre of the hip-bones, are carried most easily, being directly over the line of the centre of gravity. When a weight is carried away from this line the centre of gravity is displaced, and, in proportion to the added weight, occupies a point more or less distant from the usual position until, perhaps, it is so far removed from this that a line prolonged downwards falls beyond the feet, the man then falls, unless by bending his body and bringing the added weight nearer the centre, he keeps the line well within the space which his feet cover. In the distribution of weights then, the first rule is to keep the weight near the centre; hence the old mode of carrying the soldier's great-coat on the back of the knapsack was a bad one, as it put on weight at the greatest possible distance from the centre of gravity.

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* The *astragalus* and *os calcis* are two bones which form a bridge for the support of the two bones of the leg (tibia and fibula).

2. The weights must in no case compress the lungs, or in any way interfere with the respiratory movements, or the elimination of carbonic acid gas from the lungs, or hamper the transmission of blood through the lungs, or render difficult the action of the heart. The old cross-belt and pouch combination was one of the worst conceivable arrangements in these respects.

3. No important vessels or nerves should be pressed upon. This is self-evident. An example of neglect of this rule is the old regulation knapsack, the straps of which so pressed on the axillary nerves and veins as to cause numbness of the hands, and often swelling of the hands and forearms.

4. The weights should be distributed as much as possible over the several parts of the body.

Those whose daily vocation is weight-carrying usually carry their weights either (1) on the top of the head—because the weight is then completely in a line with the centre of gravity and in movement is kept balanced; this method for obvious reasons cannot be used by the soldier; or (2) on the top of the shoulder-blades at their broadest point above—because at this point the weight is well over the centre of gravity, and it is also disposed over a large area of the ribs by the pressure of the shoulder-blades; or (3) on the hip bones and sacrum—because the weight is near the centre of gravity, and is borne by the strong bony arch of the hips, the strongest part of the body. Besides the foregoing, great use is made of the principle of balancing by those who have to carry great weights.

Military wheel-barrows and push-carts.—Several varieties of military wheel-barrows, light push-carts and the *roulesac* (which is a small bicycle cart, detachable so that four men can carry the different parts), have been devised and introduced into some European armies for carrying part of the equipment of the men. *Roulesacs* are chiefly used for part of the equipment of soldiers who by reason of fatigue, or through accident, have to be excused from carrying their knapsack, etc. It has been found to be applicable to part of the equipment sections also, and it is possible that by greatly lightening the load the soldier has to carry, it may have some influence in modern tactics. Its great disadvantage is that any one part getting out of gear destroys its utility.

The use of a light push-cart has been suggested—one for each section of 25 men. This cart carries the men's great-coats, entrenching tools, and 100 rounds of ammunition for each man, the man carrying his rifle, bayonet, accoutrements, 50 rounds, haversack, mess tin, and water-bottle. The pattern of the cart is such that they can be pushed by the men in turns, or drawn by an animal. It should be strong enough to go over any ground that can be used by the men, and, if necessary, be provided with drag-ropes. Anything that can be done to lighten the burden the soldier has to carry will increase his marching power and make him less liable to break down.

PART IV.

PREVENTION OF DISEASE IN PEACE AND FRONTIER WARFARE IN INDIA.

A.—Introduction.

Recent orders in Home Army regarding sanitary committee in future campaigns.—The serious attention which has been given to the subject of prevention of disease in war by the Army Council at Home, has resulted in the promulgation of a series of regulations instituting the formation of a Sanitary Committee on the outbreak of future hostilities, laying down its duties and responsibilities, as well as introducing a method of instruction in army sanitation. The following is a summary of the action taken at Home in connection with the generalisation of hygienic knowledge.

Epitome of recent orders in Home Army.—On the mobilisation of a body of troops for active service in the field, a sanitary committee will be formed. It will act under the orders of the General Officer in Command. It will advise him in all matters concerning the maintenance of the health of the troops under his command. A combatant field officer is to be detailed as president, and in addition there will be two members not under the rank of field officer—one an officer of the Royal Engineers and the other of the Royal Army Medical Corps. The composition of the committee has evidently been carefully thought out, and if suitable selections are made it should be able to avoid the many pitfalls which are usually associated with the word sanitation. The duties of the committee thus formed cover very extensive ground. Among other points it is laid down that it will satisfy itself that sanitary materials and appliances of every description required by the force are forthcoming, and that a sufficient reserve supply is maintained; it will assist generals and medical officers in maintaining the health of the troops by co-ordinating, not only the work of the different military branches, but also the military and civil sanitary organisations of the locality in which they happen to be; it will initiate schemes and serve as a board of reference for the solution of sanitary problems; it will visit and inspect stations occupied by troops, advise local authorities regarding necessary sanitary measures, and further in every way the maintenance of satisfactory sanitary conditions. In a word, it will be responsible for every matter connected with the health of troops in the field. It has been given wide and far-reaching powers. The practical sanitation of regiments on service will be placed under the superintendence of an officer, who has been through a class at the

School of Army Sanitation; and in each battalion will be formed a sanitary section, consisting of a non-commissioned officer and eight men, who have been similarly trained.

In order to provide for instruction in sanitation throughout the Army, a manual on the subject has been issued by authority.* It contains such theoretical and practical information as is considered useful and necessary to the soldier. Among many other subjects it deals with the protection of the water-supply from contamination, the sterilisation of water, the different sanitary appliances of armies and their uses, the care and preservation of camping grounds and general rules of cleanliness and health. All ranks are required to make themselves conversant with its contents, and it forms an additional subject for examinations and lectures. The cadets at Sandhurst and Woolwich are required to make themselves proficient in the manual, and will be examined in it at their final examination. A course of lectures on it has been added to the Staff College curriculum. After the 1st March 1908, all lieutenants were required to pass in this subject before promotion to the rank of captain. Lectures are given, preferably by the sanitary officer of the command, at various stations; and regimental officers are expected to instil the principles of the new science into the minds of their non-commissioned officers and men. In addition to the above, a school of army sanitation has been formed at Aldershot, analogous to the school of musketry and signalling classes, at which officers and non-commissioned officers will be practically trained and granted certificates of proficiency. The classes are constituted as follows:—(1) Classes for officers, which last for a month, and embrace all the subjects in the manual; (2) classes for regimental non-commissioned officers and men, who are trained to perform the duties of the sanitary section when on active service; (3) classes for non-commissioned officers and men of the R. A. M. C., who are instructed in practical sanitation and the sterilisation of water. It is clear that the Army Council attach great importance to this new departure. They have worked out what is evidently a far-reaching scheme, and in the course of time it should make itself felt throughout the Army. Without doubt the British Army has hitherto been left far behind in the teaching and practice of sanitation, and the measures which have been outlined above should help to make up some of the leeway. The practical results to be achieved will depend to no inconsiderable extent upon whether the system can be kept unhampered by the fads of faddists and the vagaries of specialists. The regulations that have been issued appear to be well adapted to achieve the results aimed at, and it may be confidently anticipated that their influence will make themselves widely felt in future campaigns. It is urgently necessary that similar sanitary organisations be started in India.

* *Manual of Military Hygiene*, 1907.

The sanitary condition of our Army in India is progressively improving.—The reduction of sickness and inefficiency that would be effected by thoroughly carried out preventive measures in an Army on field service would appreciably reduce the accommodation necessary for the sick, the ambulance required to transport them to the base, and proportionately lessen all other expenditure arising in consequence of this reduction. It is not to be considered that we are in any sense behind the times in our modern sanitary methods in India. There is scarcely a single proved practical preventive measure of recent times applicable to our Army in India that is not in operation in one form or another. That the sanitary methods adopted have progressively improved the health of the Army of our Indian Empire is well demonstrated by the *Annual Reports of the Sanitary Commissioner with the Government of India*, the figures of which are probably the most reliable mass of statistics published in any country. "The health and sanitary condition of our Army in India has rapidly improved during the last 30 years; if we go back 50 years, the mortality of our British soldiers in India has been reduced to nearly five times less than it was then. From 1891 to 1900 the numbers constantly sick in the British Army in India was 8·6 per cent of strength, during the quinquennium 1901-05, it has been 6·09, which is equivalent to an increased strength of 1,607 fighting men on mobilisation."*

Sanitation and preventable disease—their significance.—The importance of the factors of sanitation and preventable disease in connection with modern warfare is now so universally admitted that it is scarcely necessary here to emphasise their significance. The later methods of conducting campaigns on an enormous scale adds considerably to the sanitary difficulties to be contended with, chiefly by reason of the largeness of the forces employed in fighting and their aggregation on a comparatively confined area; such increased density of population considerably enhances the cares, responsibilities and duties of the sanitary officer should epidemic disease arise. Modern methods of fighting may necessitate the use of an entrenching cover where men are closely packed almost underground, and this may, in either aggressive or defensive positions, be the state of existence for days, weeks, or months. It will be at once obvious that sanitary and precautionary measures that might prevent the occurrence of epidemic disease and even combat it successfully if it occurred in such comparatively small forces as take part in our ordinary Indian Frontier campaigns, would fail when, say, the health of an Army of quarter of a million had to be safeguarded. All our campaigns in India have been for years on a relatively small scale. "It was hardly surprising that when military operations on a comparatively large scale were undertaken in South Africa, the arrangements, which had hitherto been proved to be satisfactory, completely broke down."

* *Notes on the Prevention of Disease*, p. 1, Army Head-quarters, India, 1907.

Perfection of Japanese medical and sanitary organisation.—The Japanese have undoubtedly brought their medical and sanitary arrangements in the field to a wonderful pitch of perfection. Their thoroughness and mastery of detail in all things connected with the medical service in the field is a subject that arouses the admiration of military and medical officers of all Armies alike—all officers and others attached to the Japanese Army in the late war have unanimously expressed their opinion as to the incontestible merits and the success of the Japanese sanitary and medical service generally in the field.

Result of the work of Japanese medical service in Manchuria, etc.—At the end of a war, when we come to consider the results of the medical and preventive work, the best standard we possess is the proportion of inefficiency from sickness and deaths from preventable disease, as compared with inefficiency and deaths from wounds inflicted by the enemy. In former wars in Europe the actual deaths from disease as compared with wounds was 6 to 1, but in later times the general average has been 1·18 to 1 respectively. If we base our opinion on this standard, the success of the Japanese was phenomenally great, and the following table shows the marvellous record achieved in the late war. Their ratio was 1 death from wounds to 0·37 from disease, that is, the deaths from disease was only one-third of those in wars in Europe in *recent* times (during the last 40 years). Compared again with their experience in the preceding wars with China it is still more noteworthy :—

	China-Japan War.	Boxer Campaign.	Russo-Japanese War.
Wounded to sick ...	1 to 6·93	1 to 4·37	1 to 1·15
Deaths from wounds to deaths from disease. ...	1 to 12·09	1 to 1·97	1 to 0·37

The following table is also highly interesting :—

	Casualties in the field of battle.	Casualties in sieges.	Casualties in field and sieges combined.
China-Japan War ...	1·35 per cent.	1·69 per cent.	1·37 per cent.
Boxer Campaign ...	2·66 ,,	...	2·66 ,,
Russo-Japanese War	13·65 ,,	17·79 ,,	14·58 ,,
European War ...	12·97 ,,	17·51 ,,	13·99 ,,

The following table gives the percentage of admissions and of deaths caused by disease :—

	China-Japan War.	Boxer Campaign.	Russo-Japanese War.
Percentage of sick ...	59·20 per cent	34·88	36·04
,, of deaths and disease ...	9·29 per cent	4·33	2·99

On comparing the monthly sick reports in time of peace in 1903, with those during the late war, it is shown that in one Army Corps there was 6·42 per cent. of fresh cases of sickness as the lowest record. Another reported 11·18 per cent which was the highest. The average cases of sickness reported in peace was 10·31 per cent.

The foregoing statistics lose some of their value by not giving figures of the average strength of the forces to which they apply for the periods of the war; nor do they show on what strength the percentages were calculated. We cannot therefore use either the gross figures or the percentages for purposes of exact comparison. Practically all who have dealt with the subject of medical statistics of the late war, and with the diminution in the proportion of deaths from disease to deaths from wounds, have not drawn attention to the great alteration in this proportion, namely, the very large increase in the number of wounded and killed as compared with that of most recent wars. Great increase in wounded influence this proportion just as much as great decrease in disease, and the closer one examines the figures the more one is forced to the conclusion that the former and not the latter condition has been the chief influence at work in determining the marked alteration in the proportion of deaths from disease to deaths from wounds in the Russo-Japanese War, as compared with the immediately preceding wars.*

Casualties, Russo-Japanese War—1904-05.

	Killed.	*Wounded.*	*Missing.*	*Casualties.*	*Total Casualties.*
Officers ...	1,657	5,307	53	7,017	201,973
N.-C. O.'s and men ...	41,562	148,366	5,028	194,956	

These figures are up to 30th June 1905 for Manchuria, and to the end of August 1905 concerning troops in Korea and Saghalin.

The proportion of officers killed to officers wounded was ... 1 to 3·25
Ditto N.-C. O.'s and men ... ... 1 to 3·56

Number of patients admitted into Field Hospitals from beginning of Russo-Japanese War to 31st August 1905 :—

	Wounded.	Accidents.	Infectious or contagious diseases.	All diseases.	Total.
Cases ...	146,813	16,456	17,866	203,270	384,405
Recovered ...	15,018	4,147	2,044	23,063	44,272
Died ...	8,304	237	5,961	6,850	21,352

Infectious diseases in Japanese Army in Manchuria, etc.—The proportion of deaths from infectious and all diseases (12,811 being the total deaths due to sickness) to that of deaths from wounds was 1 to 4.†

Comparative table of infectious diseases per 1,000 men.

	Cholera.		Enteric fever.		Dysentery.		Malarial fevers.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
China-Japan War ...	82·77	50·86	37·14	10·98	108·96	15·72	102·58	5·29
Boxer Campn.	...	...	36·42	12·14	108·71	33·65	95·61	2·20
Russo-Japan War ...	...	...	9·26	5·16	10·52	2·68	1·96	0·07

This table is up to the last day of May 1905 as regards the Russo-Japanes War.

* *Journal of the Royal Army Medical Corps*, December, 1906.
† Lecture given by BARON TAKAKI, F.R.C.S., Eng., D.C.L., late Director-General, Medical Dept., Imperial Japanese Army, at St. Thomas Hospital, London, on 11th May 1906.

In the foregoing table the disappearance of cholera is noteworthy, as are also the facts that typhoid fever was about four times less prevalent, and dysentery about five times less prevalent, whilst malarial fevers were about 50 times less prevalent in the latter, as compared with the former wars.

"These remarkably good results were chiefly due to the progress made in the medical organisation as regards food, drink, clothing, camping grounds, etc., and to the great pains they took to exterminate flies and to prevent them from coming in contact with the body, articles of daily use, and into the dwelling houses. Nets were used for windows and doors of houses to prevent flies coming in, and also to protect exposed parts of the body. The extensive use of muslin nets against flies, and at the same time against mosquitoes, may possibly be responsible, beside the improved sanitary organisation, for the remarkable decrease in the number of typhoid fever, dysentery, and malarial fever cases" (Surgeon-General TAKAKI).

Were the Japanese to have had the usual average number of sick to wounded that we have in Indian Frontier campaigns, they would have lost to the force from inefficiency due to disease over 2,000,000 men.

Sick soldiers are an incumbrance in the field.—Men inefficient from sickness are an incumbrance in every sense to the Army, requiring medical care, special accommodation and transport to the base. It is unnecessary to remind you that in the presence of rapidly growing inefficiency from sickness in the field, military operations may have to be considerably postponed, as occurred in South Africa at Bloomfontein.

Importance of a low average daily sick-rate.—A low average daily sick-rate in units is as important as a high average number of marksmen in the annual course of musketry, and a low number of men falling out on a long march as important as a comparatively clean regimental defaulter's sheet.

Inefficiency from communicable disease.—Most of the diseases causing inefficiency on field service are of the communicable kinds which may be acquired by the healthy from those infected. They are chiefly due to living micro-organisms of the vegetable or animal kingdom; for example, we have typhoid fever, dysentery, epidemic diarrhœa due to special bacilli, whilst malarial fevers are due to a protozoon.

Danger of undiscovered and latent disease in tents and huts of units.—The great danger of undiscovered or latent disease in tents and huts is that in a longer or shorter time one or more of the other occupants will suffer from it, and so on; where it can be communicated through the air or by contact, the crowded condition of tents, and the comparatively small amount of cubic space in them favour such infection.

Necessity for education in military hygiene.—Medical advice and hygienic rules can be given by the medical officers of units, but it is only by the daily and constant care of the men, and by the education of them in the right methods of preserving health that they will keep well.

It is unnecessary for me to emphasise to the Gurkha officers here, in Lansdowne, that the influence of the British officer with his men is paramount. The same may be said of all branches of the service. Let the British officer be convinced as to the potency of properly carried out hygienic measures in reducing sickness and inefficiency in the Army, impart his conviction to his men, and they will carry out his ideas cheerfully. Officers should realise that a low percentage of sick in their corps is as important a sign of efficiency as that of no men falling out on a long trying march. It rests mainly with the British officer to teach his men how to keep well and how to stand hardship and fatigue.

B.—General Remarks on Infectious Diseases.

Meaning of infection and contagion.—Much unnecessary confusion exists as to the difference between the terms *infection* and *contagion* as applied to certain classes of diseases. A contagious disease is, as the word signifies, one brought about by actual contact, direct or indirect, with a person previously affected, as occurs in itch, ringworm, etc., or by the direct transmission of the virus through an intermediate individual, provided that the micro-organism has not multiplied outside the body. The term is usually applied to a disease that is capable of being communicated to healthy persons by actual contact with those who are affected. Syphilis is eminently contagious, either directly from one person to another, or indirectly, as by smoking an infected pipe. It is thus seen that contagion is eminently a limited type of infection. The term *infection* is mostly applied to diseases that are communicable through germs from air, water or food. The disease can pass from one person to another without any immediate contact between the two. There are various ways in which this may happen—by the discharges from the patient, expectoration, from the skin, clothing, infected dust, etc. All infective diseases are likewise contagious. It is, however, difficult to draw a hard-and-fast line between infectious and contagious disease, nor is this necessary so long as we understand what the terms signify.

Some diseases are communicated by the discharges only, *e.g.*, cholera, bacillary dysentery, by their germs gaining access to the alimentary tract through water, air or food; influenza, measles, pneumonia, and tuberculosis through the expectoration; typhoid fever through the stools and urine. Some diseases are acquired through insects, as malaria through infected anophelines, bubonic plague through infected rat fleas, relapsing fever through the bed bug; some through wounds and scratches, as tetanus and hydrophobia.

It is probable that in the future other diseases will be shown to be carried in this country by insects or animals. Flies are active carriers of typhoid fever, cholera, and dysentery bacilli, and in many towns in India play an important part in the spread of these diseases.

Meaning of specific disease.—*A specific disease* is one which is conveyed by one cause alone, a particular species of microbe or protozoon, and no other. Thus malarial fevers are due to the introduction into the body of one or other form of the malarial parasite, and by no other cause.

General infective diseases.—The *general infective diseases* are those in which the microbes develop and multiply in the blood stream, so that inoculation of a sound person (or one not protected) with the blood of a person suffering from such a disease, would almost certainly cause the disease if a sufficient quantity were so inoculated.

Endemic diseases.—Some diseases occur in certain places only, and are more or less constantly present in those places; they are said to be *endemic.* Of this kind we have in India malarial fevers (and the sequels arising from them, such as enlargement of the spleen, anæmia, malarial cachexia), dysentery, infective diarrhœa, kala-azar, etc.

Epidemic diseases.—Every now and then we have out-breaks of disease which attack many persons at the same time and in the same place, spreading far and wide. Diseases beginning and spreading in this way are said to be *epidemic.* Epidemic diseases are to a large extent preventable; most of the endemic diseases can also to some degree be kept under control, and we can generally lessen their severity and prevalence. Some epidemic diseases have entirely disappeared from certain countries and endemic diseases have ceased to exist in others. The term *pandemic* is applied to an epidemic disease which spreads widely and rapidly over a country, or invades several countries rapidly one after another. Influenza and dengue are typical of this class of epidemics.

When a disease which is ordinarily epidemic occurs occasionally in a community as an isolated case it is said to be *sporadic.*

In areas of epidemic disease the specific cause may in different cases remain in the soil, in water, or in the bodies of the inhabitants, or be kept up by the additions of fresh cases of the disease in the community. In epidemic disease the conditions which favour the continuance of the life of the specific cause are as a rule of a temporary nature, unless there are fresh importations of that cause. During an epidemic of cholera cases of diarrhœa occur and it is highly probable that some of these cases of diarrhœa are really mild ones of (ambulant*) cholera. These cases are often not discovered but are active disseminators of the disease.

In epidemics where the disease is imported and does not take root, it is probable that the specific microbe is chiefly contained in the bodies of those infected, reaching soil and water from the dejecta, but the soil and water affording only a limited period of life to the germ,

* See article *Cholera*, Part IV.

the conditions favouring the continuance of the disease cease and the disease dies out. These conditions in the life-history of germs are typically illustrated in the *explosive epidemics* of enteric fever and cholera that occur in India.

Epidemic disease, even when repeatedly imported into places unfavourable to its continuance, neither extend nor remain. Cholera and plague, and even yellow fever, have several times invaded the United Kingdom during the last fifty years, but never took root there nor spread epidemically. We are becoming more doubtful about the occurrence of spontaneous epidemics of disease in communities, and are more inclined to the view that importation, often unknown and undiscovered, is at the bottom of most such epidemics. We cannot at present deny the possibility of such spontaneous epidemics arising from latent foci of specific bacilli or their spores, and of such bacilli possibly being suddenly rendered virulent by some change in the conditions of their physical environment, and then in this state invading the human body. Such passage of infective microbes through man in many diseases intensifies the virulence of such microbes.

With endemic disease there are always local conditions which favour its continuance in the area in which it occurs.

The spread of all epidemic disease is lessened by all ranks living healthy lives, by living in accordance with the rules laid down in the foregoing pages—keeping their bodies clean, using pure water, wholesome food, living in well-ventilated barracks and surroundings, obeying the instructions issued for their guidance by medical officers of units, cantonment sanitary officers, and divisional sanitary officers and others in authority on field service.

During periods of epidemic disease, no change should be made in the ordinary regular habits of daily life. Special precautions are necessary as regards water-supply, the food and cooking, avoidance of fatigue and unnecessary exposure, attention to the sanitation of the barracks, huts, tents and their surroundings, but in this latter such measures as disturbing deposited or buried filth are to be avoided. There should be no apprehension of acquiring infection; such fear predisposes to disease. It is rare for healthy people living in healthy barracks and amidst clean surroundings to acquire infectious disease.

The white cells of the blood, especially those known as *phagocytes*, act as scavengers of the blood, and, as a rule, take up any germs reaching that fluid But when we are in poor health, or when in good health the number of germs reaching the body is greater than the phagocytes can deal with, these germs multiply and disease arises. In this case we can only endeavour to keep the patient alive until the body reacts successfully against the effects of the germs. In some cases these germs are not virulent and do not endanger life, but in

many cases they tend to overwhelm the vital processes by the poisons they produce. In this latter case the medical officer attempts to keep the patient alive until the natural powers of getting rid of the germs are brought forward.

Whilst we have made considerable advances in our knowledge of the history of many infectious diseases we have still much to learn regarding their epidemiology and bacteriology before methods of arresting and controlling this class of disease in cantonments can be considered perfect. There are in reality few disease-germs regarding which our knowledge can be said to be complete. Some diseases attack both men and animals and are communicable from the one to the other. Regarding some we only know their effects on man and how they may be cultivated *artificially* outside the body, whilst we know nothing about their conditions of natural life. The bacteriological studies that are being carried on throughout the civilised world are slowly giving more light, and helping us to ascertain the most potent methods of arresting and controlling disease. The main basis of all preventive measures in infectious disease is a knowledge of the conditions of the life of specific bacteria.

It is unfortunately the fact that the germs of specific disease may exist in apparently healthy persons, through whom these germs may be disseminated in communities. It is difficult to deal with such "carriers" of disease, partly because they are mostly unaware of the fact that they are carriers, and partly because their isolation is extremely difficult to carry out efficiently in large communities.

Some infectious diseases are to a considerable extent under our control when all the methods of modern sanitary science cau be properly applied—notification, isolation, disinfection, vaccination and other sanitary measures. This is the case with small-pox, cholera and certain other infectious diseases. Other diseases such as influenza and dengue appear to be uninfluenced by precautionary measures. Others again, from their widespread nature, and the want of knowledge on the part of the people, appear to be only slightly amenable to preventive measures, *e.g.*, tuberculosis of the lungs, although, theoretically, this is essentially a preventable disease.

In many of these diseases the definite cause is some special form of micro-organism and the same explanation as to cause is inferred in the case of the others on account of their commou characters.

All diseases due to bacteria in the system have a shorter or longer period of incubation, a period of rapid multiplication of germs associated with severe symptoms, and a period of decline. Exposure to infection may not produce disease as the actual numbers of microbes introduced into the body may not be sufficient, the virulence of the microbe may be very low, or the resistance of the tissues may be sufficient to prevent invasion.

Infective diseases.—These are practically all communicable from one person to another. Each disease has a definite duration No symptoms occur for some time after infection takes place. The interval of time between the actual infection and the appearance of the first signs or symptoms of the disease is called the *period of incubation.* When the incubation period has elapsed the typical symptoms of the disease appear and last for a certain time during which death may occur. After the active period of the disease is survived recovery usually takes place. As a rule one attack of these diseases is not followed by a subsequent attack in the same individual within a certain limit of time: the attack confers immunity from that disease. There are several exceptions to this, *e.g.*, cholera may occur in the same person more than once and that even within a year; plague has frequently attacked the same person more than once, even small-pox may occur twice in the same person, though this is exceedingly rare. It is important in the prevention of the spread of infectious disease to remember that the period of infection lasts from the earliest symptoms (in one or two cases, such as measles and mumps even before such symptoms appear) until the patient has completely recovered, which in the eruptive fevers means until the last scales have fallen from the skin, and in the case of cholera and enteric fever until all bacilli of the disease cease to be discharged in the excreta (see *Enteric Fever* and *Cholera*). The periods of incubation given below are the averages from large numbers of cases, but they may be extended or lessened under varying circumstances, such as the dose and degree of virulence or attenuation of the microbe received, degree of susceptability or partial immunity of the patient, etc.

The following table gives the periods of incubation and infectiousness of the chief communicable diseases met with in troops in this country :

Diseases.	*Period of incubation.*	*Periods of infectivity.*
Small-pox	12 days.	6 weeks usually.
Dengue	3 days, may be 5 or 6.	2 " "
Influenza	A few hours.	1 or 2 weeks.
Relapsing fever ...	A few hours to 12 days, commonly 5 days.	4 weeks usually.
Enteric fever ...	5 to 21 days, commonly 11 days.	6 " "
Cholera	A few hours to 5 or 6 days.	2 " "
Malaria	1 to 3 weeks.	Not transmissible from person to person except by transfusion of blood and bites of infected anophelines.
Plague	2 to 5 days.	3 weeks or more.
Tuberculosis ...	3 weeks	.....
"Sand-fly" fever ...	3½ to 7 days.	2 days.

The *period of infectivity* means the time during which the disease may be communicated to others.

Types of acute infectious disease.—Most cases of acute infectious disease occur in three forms—*mild*, needing little active treatment; *malignant*, in which remedies can do little good; and a third class between these two in which much may be done by nursing and skilful treatment.

Spread of infection.—1. *By air.* The germs of small-pox, measles, chicken-pox, mumps, influenza and tuberculosis can be carried by the air. In most infectious diseases, the probable distance that germs travel in air is short, and it is likely that only in the case of small-pox, influenza and tuberculosis, can the infection be carried any great distance.

2. *By water and food.* Typhoid fever, cholera and dysentery are notoriously water-borne diseases. Infected milk may also spread these three diseases and also tubercle and possibly measles. In Europe infected milk spreads diphtheria and scarlet fever.

3. *By clothes.* Small-pox and plague have a special proclivity to lie dormant for long periods in clothes and in the furniture (especially if upholstered) of the sick-room. Infected books and toys may also be instrumental in spreading infectious disease.

4. *By man and insects.* Man is a carrier of many diseases and the infection may be from the lungs, skin, fæces and urine. We know that various insects carry infectious diseases; flies carry typhoid fever, cholera, and dysentery; mosquitoes carry malaria, and "sand-flies" carry "sand-fly" fever.

Life-history of the house fly.—House flies for choice lay their eggs in partially decomposed human excreta, in cow-dung and horse-dung, in fermenting vegetable matter, on all of which the larvæ when hatched out can feed. The fly may burrow into rubbish heaps, manure, etc., to deposit its eggs. In a temperature between 72° F. and 95° F., when combined with animal food, a sufficiency of moisture (which is essential), and the presence of fermentation processes, development is rapid and uninterrupted. The eggs take from one to three days to hatch into larvæ which continue as such for a week and then develop into the pupæ, which proceeds to form the imagines or flies. The process may be gone through in 8 days, but it usually occupies 12 to 20. In this country the following are the average times in the different stages of development *:—

Stage.	Hot weather.	Cold weather.
Eggs	One day.	Two days.
Larvæ	Five days.	Fourteen days.
Pupæ	Three days.	Five days.

* Major Aldridge, R.A.M.C., *The Spread of the Infection of Enteric Fever by Flies*; *R.A.M.C. Journal*, 1904.

The imago is at first underground, or in the midst of a heap of rubbish, whence it works its way by the aid of the ptilinum or frontal sac. When first set free from the pupal case it is of a greyish colour and its surface moist; before it can fly, its wings have to dry. The imago is fully mature in about 12 days, and eggs are deposited about four days after the sexes have paired; there are from 120 to 150 eggs in each brood.

Flies cannot breed or multiply when collections of moist organic matter are absent, as such organic matter is essential to the growth of their larvæ. Human excreta are in this country the chief source of the common house fly. No place upon which ordure is deposited can be said to be of itself unsuitable for the development of flies, provided flies can reach the ordure, and provided the maggots can either by falling or crawling reach a place in which to pupate. For the larvæ of flies 48 hours is sufficiently long feeding time to permit of the post-maggot stages being gone through. After 48 hours the maggots do not require moisture beyond any which they may be supposed to get from the air.

A host of flies in an inhabited place is proof that there is defective removal of dry and liquid refuse of some kind. A plague of flies in a locality where general infective disease exists is, in some cases at least, likely to be associated with, and partly responsible for, the dissemination of such disease by carrying infective microbes about on their feet, wings, and bodies. Camps or barracks which are infested with flies will sooner or later become foci of infective disease, and probably more than one such disease.

Prevention of the spread of infectious diseases.—We cannot adopt any set plan for the prevention of all infectious diseases; the method of procedure in the case of small-pox is distinct from that adopted in plague, different for cholera, and so on. The measures adopted to prevent the diffusion of infectious diseases are based on what we know of the natural history of these diseases.

The *spread of infectious diseases is best prevented* by carefully obeying the instructions given by sanitary or other authorities. These instructions usually include the following precautions:—

1. **Isolation.**—Infected persons should be at once separated from the healthy and sent to hospital.

2. **Quarantine.**—Those who have been exposed to infection should be isolated separately and kept under observation until the period of incubation of the disease in question has expired. The segregation of persons suffering from infective disease (and of those who have been in contact with such persons) from the healthy is of the utmost importance. In the case of such diseases as small-pox, typhus fever, plague, and cholera, all persons who have been in contact with such should be segregated. This should be cheerfully submitted to as it forms an important part of the measures for preventing the spread of infection.

Segregation of "contacts" has to be carried out for the length of the incubation period of the disease for which it is adopted. The periods of incubation are given on p. 401.

Temporary infectious diseases' hospitals.—The least expensive and probably the best temporary infectious diseases' hospitals are made from bamboo and matting both as regards roof and walls. In very hot places a thatch, grass or *chapper* roof, supported on wooden posts, is preferable. The bamboo mat walls should be arranged in strips so that they can be raised; the patients may thus live almost as if in the open air. The floor should be raised a few feet above the level of the surrounding surface.

Tents may also be used as temporary hospitals, those in which the side-walls can be completely raised, such as the European privates' tents, being the best. Old or condemned tents may be used for this purpose.

3. **Disinfection.**—The disease-germs must be destroyed, wherever this is practicable.

The infective germs may attach themselves to the persons, clothing and bedding of infected persons, to a less extent to the walls, ceilings, fittings and floors of rooms. In most cases the admission of abundance of light, free ventilation and thorough scrubbing with soap and water is sufficient. Clothing and bedding must be thoroughly disinfected by steaming or the use of liquid disinfectants.

4. **Artificial immunisation.**—In the case of small-pox the disease can be checked in its spread and could eventually be stamped out by efficient vaccination and re-vaccination, which confer immunity from the disease; plague can be prevented for six months by anti-plague inoculation, typhoid fever for 1½ to 2 years by anti-typhoid vaccination, and cholera for several months by anti-cholera vaccine.

A century and a half ago inoculation of small-pox virus was practised in England as it is now by various tribes of hillmen in the Himalayas. A large number of our Gurkhas and Garhwali troops before enlistment have been so inoculated. In this the active living germ of the disease is introduced, and the result is that not only do the people die from it, but epidemics of it are spread by this practice. We now vaccinate after the germ or virus has been passed through the calf. We give the calf human small-pox, which in its transmission through the animal is attenuated and robbed of its virulence. It does not affect the calf seriously, but produces a series of blisters from which the fluid is abstracted and mixed with chemically pure glycerine. With this capillary glass tubes are charged and from these tubes man is vaccinated. This vaccination in the large majority of cases protects from small-pox. Inoculation against typhoid fever is based on the

same principle, except that in the latter, the killed germs are inoculated on two occasions at intervals of 8 days, giving rise to slight general disturbance and protecting in most cases from the disease. Unfortunately this protection against typhoid fever is not absolutes nor does it continue as a rule for more than 1½ to 2 years, and the hopes originally entertained that it would eradicate typhoid fever from the Army have been disappointed. But these 1½ to 2 years' protection is important to the young soldier, especially after arrival in India, as he is then at the most susceptible age for acquiring the disease, and his resistance is lowered by reason of his change of life and the process of acclimatisation he is going through on arriving in a warm climate. Of 1,963 men inoculated at home in 1906 and 1907, no cases occurred in the year, whilst there were 56 cases with 7 deaths among those not inoculated, the respective ratios being *nil* and 6·3. During the same period 2,130 men were inoculated in India; among these there were 8 cases with 1 death, while among those not inoculated there were 770 cases with 101 deaths.

Similarly we may obtain protection from other diseases, *e.g.*, by inoculating animals with the germs of diphtheria, tetanus, etc., and then obtain a serum from their blood which protects man from the action of the living germs which gain access to the body. There is great probability that in future years protective inoculations will be practised against many other infective diseases. The whole subject of such inoculations is a rich field for investigations in connection with preventive medicine.

The chief protection against attacks of particular infectious germs is entirely personal, residing in the person's own system, especially in the white blood cells and the serum, the former eating the germs and the latter neutralising the poisons created. The amount of protection therefore varies very considerably.

One of the means of protecting, and in some cases even treating, certain infectious diseases at the present day, is to increase the protective power of the white blood cells and serum. The general method of doing this is by introducing small doses of the poison which brings about a stimulation of the white blood cells and the creation of neutralising antitoxins in the blood. This is, for example, the basis of the treatment of tuberculosis by injecting small doses of tuberculin. The amount of protection varies in different persons and in the same person at different times. The chief factors affecting this protection are—age, errors in diet generally, excesses in alcohol, fatigue, hardships, injury, and inclement weather. The effect of age is seen in the great liability of our young European soldier to acquire typhoid fever in India. This age influence to enteric is emphasised when it is associated with fatigue and exhaustion, and especially under the strain of campaign life, or during the change from a temperate to a hot climate by which there is created a disturbance in the physiological work-

ings of the body which is accommodating itself to the change, and with this disturbance there is lowered resistance. When vitality is below par, or the dose of the poison which has gained access to the system is large, protection is overcome. The maximum of protection is normally afforded by persons being thoroughly fit and leading healthy lives amidst wholesome surroundings. Protective inoculations aim at increasing the resisting powers to the action of disease-germs. In protective inoculations we inject small doses of the microbes and their products to protect from future attacks or lessen the severity of such attacks if they occur.

5. **Notification.**—When a case of infectious disease occurs it should be notified to the senior medical officer, the principal medical officer, and the sanitary authorities, who will take prompt steps to stop the spread of the disease. The practice of suppressing information regarding infectious disease either in cantonments or on field service is most dangerous. When made known in cantonments or on field service, we obtain the co-operation of every official concerned in the eradication of the disease, and such eradication is, as a rule, speedily effected; whereas when suppressed new foci of the disease are started it makes headway rapidly; under this circumstance, it is extremely difficult to stamp out the disease. The early recognition of acute infectious diseases is of great importance from the standpoint of prevention in the Army on account of the spread of infection if precautions are not taken. This is specially the case in all large bodies of men in barracks and camps.

Method of investigating the origin and course of infectious disease.—When an epidemic disease, other than such rapidly spreading and uncontrollable diseases as influenza and dengue, breaks out in a community, one of the first duties of the local medical authorities, through their sanitary officer, is to enquire as to the manner in which the disease was imported and how it is being disseminated. In this enquiry the sanitary officer endeavours to ascertain the origin of the earliest cases. Where compulsory notification of communicable disease is rigidly enforced and practised, there should be no difficulty in this, but there are numerous reasons for evading such notifications, and in this country, at least, the disease has usually spread to several foci before this enquiry is properly commenced, and then there is the utmost difficulty in ascertaining its precise method of origin. Similar difficulties arise when several imported cases are simultaneously spread over different and widely separated areas of a cantonment or field force. Where no importation can be traced, it is possible that the germ of the disease may have been latent in the locality.

The use of what is called a "spot map" is invaluable; the sanitary officer marking on it the barracks, huts or tents in which all fresh cases occur. This at once indicates the lines of extension or decrease of the disease. As will be seen in discussing the individual diseases, the causes favouring epidemics differ; thus a widespread epidemic of cholera

is certainly due to contaminated water, and one of small-pox to the existence of a large number of persons unprotected by previous vaccination and revaccination in the community; a localised outbreak of typhoid fever in a large community—where all the community get their water and milk-supply from the same sources—is probably in some way connected with defects in the method of removal of the excreta or contamination of the soil in the affected area.

All epidemics, however, are favoured by neglected sanitation, and every effort should be made to lessen or remove all defective sanitary conditions. In all cases we should also prevent the importation of fresh cases, and, whenever possible, isolate all cases occurring in the community and endeavour by disinfection to destroy the local foci whence the disease may be disseminated. The isolation of cases means the separation of the infected from the healthy, and for carrying this out efficiently adequate hospital accommodation has to be provided. The prevention of epidemic disease cannot be efficiently carried out by fitful sanitary efforts in the presence of an existing epidemic, which, as a rule, involve the expenditure of large sums of money without mature deliberation as to the benefits to arise from such expenditure. All sound sanitary measures are previously thoroughly thought out in all their aspects, and then put into operation systematically. The prevention of epidemic disease in large cantonments and camps requires the perpetual watchfulness on the part of the sanitary authorities, and a constant state of preparedness to meet such disease should its invasion be inevitable.

C.—Elements of General Bacteriology.

Disease prevention based chiefly on bacteriological science.—Whilst one does not wish to burden you with the intimate workings of present-day bacteriological science, still it is necessary to briefly allude to the nature of disease-bacteria, how they gain access to the human system, how they grow, and how man is defended, naturally or artificially, against their attacks, in order that we may understand the bases of our present-day preventive measures.

Bacteria.—The term *Bacteria* is applied to a group of micro-organisms, the members of which belong to the lowest forms of vegetable life. It is now popularly used synonymously with microbe, germ, micro-organism. Bacteria are minute vegetable organisms of the natural order of plants called *Fungus*, the general characters of which are—that they are plants without stems, leaves, or roots, consisting of simple cells in juxtaposition, and possessing no green colouring matter (chlorophyll). In *shape* they are either spherical (cocci), and may be single or in massed groups (staphyloccoci) as occur in the blood or tissues in certain forms of septicæmia or blood-poisoning, or in chains (streptococci), occurring in the

Fig. 62.—Forms of bacteria—(*a*) Micrococci; (*b*) Bacilli; (c) Spirilla.

blood in another form of blood-poisoning ; in the form of elongated straight rods (bacilli), as met with in typhoid fever, dysentery, plague, tuberculosis, etc.; or twisted or spiral rods, as in cholera (*comma bacillus*). Let us describe the characters of these different forms in detail.

Bacilli.—*Bacilli* are elongated rod-like bodies, either straight or slightly curved varying from $\frac{1}{50,000}$ to $\frac{1}{10,000}$ of an inch long, and always more than twice as long as broad.

Micrococci.—*Cocci* or *micro-cocci* are small spherical cells which multiply rapidly by fission. They are classed according to the manner in which the cells are grouped. When they are in pairs they are called *diplococci*, as examples of which we have both varieties of pneumococci (the active causes of pneumonia) : gonococci (the infective microbe of gonorrhœa). When, owing to the manner in which fission has occurred, they are grouped into irregular masses like a bunch of grapes. they are called *staplylococci*. These are generally concerned in the production of pus, and usually occur in localised inflammations, such as boils and abscesses. There are several varieties of these. When the spherical cells are grouped in such a manner as to form single rows or chains they are called *streptococci*. These are likewise pus-producing organisms, but are concerned in spreading inflammations, and the septic conditions associated with blood-poisoning from wounds. There are several varieties of this class also.

Spirilla.—*Spirilla* or *vibrios* are thread-like cells which are more or less curved. They may be either short and formed of a single curve, as the *comma-shaped spirillum* of cholera ; or they may be long, forming corkscrew-like threads, performing active movements

Structure of bacteria.—The *structure* of bacteria is extremely simple, consisting as they do of unicellular organisms. Each cell consists of a delicate cell wall which encloses a small mass of vegetable protoplasm, in which there may be one or more vacuoles, and in some a few granules. Sometimes, external to the cell wall, there is a gelatinous envelope or capsule, which may unite the bacterium loosely to its neighbour, as is seen in the pneumococcus, and often in the plague bacillus especially *in vitro*—such a capsule is of importance in enabling us to at once distinguish micro-organisms with it from others resembling them, but not in possession of a capsule.

Habitations of bacteria in air, water, soil and earth, alimentary tract and blood.—Bacteria are found almost everywhere—in air, water, soil, dust, in our food, clothing, and on our bodies ; yet each particular species of microbe has its favourite habitat in which it grows, develops, and flourishes most abundantly. In general terms we may state that the micro-organisms of disease are specially spread about by water, food, air, dust, and flies. If it were possible to completely control all these means of diffusing disease-germs we should be in a position to prevent all diseases caused by them.

In *air* the presence of bacteria varies with circumstances. They are absent from the pure air of high mountain tops, and in mid-ocean. They are present in vast numbers in the air of crowded cities and camps, especially within crowded tents and houses. They are not given off from liquids in which they are contained, and remain in suspension in the air only when adherent to particles of dust or moisture.

Whilst ordinary expired air is sterile, the mucus and moisture thrown off in speaking and coughing contain numerous bacteria, which may remain in the air some time. The bacterial contents of *water* varies much. That of any public water-supply should contain but few bacteria as a whole, and certainly no disease-producing pathogenic bacteria. *Soil* (and *earth* generally) contains vast crowds of bacteria, whilst pathogenic bacteria are frequently also present. The human skin, like everything else exposed to dust and dirt, swarms with bacteria; the majority, however, are there by accident, and are readily removed by washing.

Bacteria are always present in the alimentary tract from the mouth to the anus; also in the openings into the ears (external auditory meatus and canal), in the lower part of the nasal cavities, on the eyes (conjunctivæ), and anterior part of the male urethra. The ducts leading from the alimentary canal to internal organs (liver, pancreas) are usually free from bacteria. The perfectly healthy body is constantly throwing off disease-germs that gain access to it.

The blood and deeper tissues of the healthy animal are usually free from microbes, but observations have shown that a small number of bacteria may pass into the blood and lymph vessels from the alimentary tract. In the state of health, bacteria do not find suitable conditions for continued growth in the human body, but when the general vitality of the body is lowered, or when any injury is present, bacteria may gain a hold, grow, multiply and cause disease. Recent experiments have shown that both fatigue and hunger are conditions of the body under which bacterial attacks are prone to occur, as resistance to their invasion is in these states greatly lowered. The very interesting condition knowm as *fatigue fever* has been by some attributed in part to minor forms of infections acquired from the alimentary canal when the resistance is low. Similarly fatigue may be a predisposing factor in the causation of specific infections, especially when combined with inadequate nourishment.

Modes of access of bacteria to human system.—Bacteria may gain access to the living tissues in various ways, and some do so through the lining membrane of any of the mucous tracts. A single layer of epithelial cells of a membrane is more readily penetrated, especially if it has no basement membrane, than a membrane provided with many layers of cells, such as the mouth and skin.

Seats of election of bacteria in the human system.—When bacteria which can exist in living tissues effect an entrance into the circulation, they have a tendency to select as a suitable nidus in which

to collect and flourish, some tissue, the vitality of which has been impaired by injury or otherwise, or some part of the blood stream in

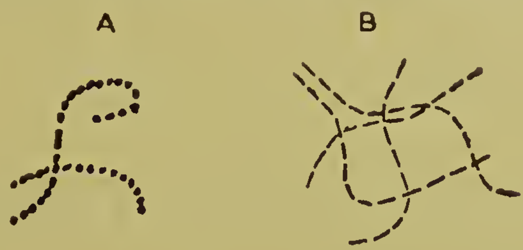


FIG. 63.—Micrococci (*a*), and Bacilli (*b*) showing fission.

FIG. 64.—Germs showing spore formation.

which the blood current is slow. Or, bacteria gain entrance to living tissues through wounds or abrasions on the surface of the body. It may be said that a perfectly healthy intact skin (epidermis) forms a strong barrier to their introduction, though they may gain access through hair follicles and the ducts of sebaceous glands, especially when rubbed into the skin by the clothes.

Multiplication of bacteria—fission.—The method of reproduction in bacteria is very simple; in it there is nothing similar to sexual reproduction. The first form is by a process of simple fission. In this the bacterial cell is divided into two by a thin membrane or partition, the two separate and become two independent individuals. Sometimes, however, they remain more or less united by a capsule. This process of division takes place with great rapidity, so that with a suitable material, which has become infected by a few bacteria, in a few hours, it contains countless numbers of them. Germs may multiply so rapidly in the body that in 12 hours a single microbe may give origin to 8 or 10 millions.

Spore-formation—Multiplication by spore-formation is a little more complicated and occurs only in the rod-shaped bacteria or bacilli. The spores are round or oval in shape and are formed inside the bacterial cell (endosporosis) in the centre, or at one end. The spores have comparatively thick walls, contain protoplasm, and are highly refractive under the microscope. The shape and size of the spores have much importance in diagnosis. For example, the spore of the tetanus bacillus is almost spherical and is of larger diameter than that of the rod containing it; the spore of the anthrax bacillus is oval, and only as broad as its parent rod. The position of the spore is also of diagnostic value —*e. g.*, in the bacillus of tetanus it is at one end, giving the bacillus the appearance of a drum-stick; in the anthrax bacillus it is centrally placed. Spores are the resting forms of bacteria adapted to maintain the life of their species under unfavourable circumstance, as is the case of the seeds in the higher plants enclosed in their seed cases.

Spores are very resistant.—Spores are the most resistant of all living bodies. They are capable of withstanding great heat and cold and unfavourable surroundings generally, and live through destructive influences that would kill their parents. Spores resist drying and the action of disinfectants to a far greater extent than the bacteria themselves. Anthrax spores have been found in bacteriological laboratories for 20 years without any loss of virulence, or of viability, whereas anthrax bacteria without spores (asporogenous) die in a few weeks when dried. They also resist a higher temperature than the mature organism.

Most bacteria when moist are killed when exposed to a temperature of 140° F. for half an hour, whereas some spores are not killed by boiling. A short action of carbolic acid solution of 1—20 kills adult anthrax bacteria, whereas their spores are only killed under this influence after many days.

In their manner of growing and multiplying disease-germs in the body are almost identical with what occurs in the fermentation of sugary solutions by yeast ferments in the production of alcoholic beverages, such as beer, brandy, etc. In the making of brandy grapes are put into vats and crushed, a sugary solution forms which is attacked by germs from the skin of the grape, or from the air, and ferment the sugar, forming alcohol with carbonic acid gas. This goes on until a certain amount of alcohol forms and the action stops. Germs go on multiplying in the body until the serum and other fluids of the body produce an antidote which prevents their further multiplication. We have typical instances of such diseases in small-pox, measles, typhus fever, typhoid fever, cholera, plague, etc. In all these diseases there is a period of incubation during which apparently nothing happens.

Organs of locomotion of bacteria.—Many bacteria are provided with organs of locomotion in the form of *flagella*. Flagella are delicate filamentous extensions of the cell protoplasm occurring in bacteria having the power of spontaneous locomotion. Flagella are sometimes of great length and in great numbers, as in the bacillus of typhoid fever; they are always extremely thin and only visible under the microscope after complicated methods of staining. Their number and sometimes their position in relation to the cell are of importance in diagnosis. The typhoid bacillus, provided with 12 to 20 flagella, is recognised from the *bacillus coli*, an inhabitant of the normal alimentary tract, which has from 3 to 6; that of cholera as seen in India only 1 or 2 flagella and these are always terminal.

Aerobic and anaerobic bacteria.—Some bacteria require oxygen or air for their growth and multiplication and are called *aerobic*—most of the microbes infecting man are of this class. Others cannot multiply in the presence of air or oxygen, and are called *anaerobic*. The germ of tetanus belongs to this group. The anaerobic germs have the power of appropriating the oxygen of unstable organic combinations, thus acting as disorganising, fermentative, or putrefactive agents. Some possess the ability to flourish in or out of air or oxygen, and are then known as *facultative anaerobic* bacteria.

Some bacteria are very active, such as those of typhoid fever and cholera, which are in constant motion, others are very sluggish, such as that of dysentery, others are non-mobile, such as that of tuberculosis.

The chief harmful bacteria.—The vast majority of bacteria are useful in nature, and neither animal nor vegetable life could be carried on without them. Of the thousands of different bacteria, only a comparatively few are harmful to man, and of those that are harmful we are at present only concerned with such as affect or may affect our Army in peace and war. Of these the chief are the bacillus of typhoid fever, of dysentery, epidemic (camp) diarrhœa, of cholera, tuberculosis of the lung, influenza, plague, and a few others. These will be specially dealt with under the headings of the diseases they produce.

Cultivation of bacteria.—The microscope is our chief means of distinguishing bacteria. We usually supplement microscopical examination by *cultivation* methods, in which a suitable culture medium is inoculated with the material to be examined and kept at a proper heat for the development of the bacterium suspected. These culture media are numerous, but broth, gelatine, solidified blood-serum, and agar-agar, are usually sufficient. Broth consists of a solution of meat extracts, peptone and salt. It is chiefly used for making cultures for animal inoculations and for observations on the chemical products of bacteria. Solid media are more generally useful, as many microbes form characteristic colonies or growths on the surface, or in the depth of these media. Nutrient gelatine, often used, is broth solidified by the addition of 15 per cent. of gelatine, and is very valuable, as it is liquefied by some bacteria such as that of cholera, whilst others do not liquefy it. It usually, however, melts at a temperature which excludes many important observations being made. Agar-agar is broth solidified by the addition of a substance prepared from seaweed. It does not melt at body temperature, is not liquefied by any organism, and is the most useful of all media to work with.

Food of bacteria.—All bacteria require for their growth and multiplication—a suitable soil, a certain amount of moisture, an appropriate temperature, a certain amount of nitrogen and salts, a certain amount of oxygen (which may be in the air or contained in the medium in which they live), and the presence or absence of light It is possible to interfere with the multiplication of disease-germs by changing any one or all of these conditions of germ life.

Without water or moisture in some form they cannot multiply. The most suitable *temperature* varies greatly in different bacteria. The majority flourish best at the temperature of the human body (between 98—100° Fahr.). Other organisms thrive best at temperatures above or below this. Lower temperatures than that named generally inhibit growth, but do not actually kill bacteria, unless applied for a long time.

Effects of light on bacteria.—*Light* is injurious to nearly all microbes, particularly bright sunlight, and especially if combined with a temperature at which the bacteria are killed outside the body. A short exposure of some disease bacteria to direct sunlight at tropical temperatures kills them; they die more slowly in diffused daylight.

Evidence that bacteria produce disease.—To prove that a particular microbe is the cause of a special disease it is necessary—that the microbe be present in every case either in the tissues or the blood; that it be possible to cultivate it for many generations outside the body; that its inoculation into a suitable animal must be followed by the appearance of the specific disease, and that the microbe must be found in the tissues or blood of the animal affected in this manner.

Disease-producing (pathogenic) bacteria.—Regarding the action of bacteria in relation to disease, we divide them into two classes—according to whether they can increase or multiply in living tissues. What we call *pathogenic* or *disease-producing* bacteria do so multiply

and produce infective diseases. The non-pathogenic micro-organisms can only develop and multiply in dead organic matter, such as the serum of the blood, pus, sloughs, etc.; these are spoken of as *saprophytic microbes*. Some bacteria can live and grow both in dead organic matter and on living tissue—these are known as *facultative* (adaptive) *saprophytes*.

Toxins or poison produced by bacteria.—As bacteria grow they produce certain poisonous chemical substances, either directly from themselves or from the organic substance which they inhabit. These poisons are of two kinds—*tox-albumins*, which are of an albuminous nature, and *alkaloidal ferments* or *ptomaines*. These bodies, when isolated from the germs forming them and introduced into living tissues, are very poisonous, producing locally inflammation, suppuration, and death of the tissues, and generally severe symptoms of constitutional disturbance. The nature of the symptoms vary with the nature of the toxins, each microbe producing its own special kind of toxin. The tox-albumins appear to have the power of killing the bacteria by which they are produced. This is very important, as sometimes bacteria are destroyed by the poison which they themselves create.

True bacterial toxins.—The true bacterial toxins have been isolated in a state of purity, but seem to be allied chemically to bodies called *albumoses*, and have properties like those of enzymes (or digestive ferments). They are extremely poisonous when injected into the blood or tissues, although in most cases harmless when taken by the mouth. They are very unstable, being destroyed by heat, gastric digestion, etc., and when kept in solution gradually become inert.

The true bacterial toxins are of two kinds: (1) Certain microbes such as those of tetanus and diphtheria produce soluble extra-cellular toxins, which accumulate in the fluid in which they are grown; (2) in many other microbes we have not been able to produce a powerful soluble toxin, and the specific poison appears to remain enclosed in the bacteria themselves, and is only set free in the body under conditions that we have not yet been able to imitate experimentally in the laboratory. These are called *intra-cellular toxins*. The soluble products formed by the bacillus of pulmonary tuberculosis has but little poisonous action, but the washed bodies of the bacillus of tubercle are extremely poisonous.

Pathological effects of bacterial toxins.—The pathological effects of these toxins vary greatly, but in nearly all fever is produced. Some are selective, acting on certain kinds of cells in the body only, such as the bacillus of tetanus which acts on the central nervous system (brain and spinal cord); others, such as the septic organisms, affect any tissues they reach. In the natural state in the body, the effect produced by the poisons varies with the amount of the toxin formed and susceptibility of the person and the tissues to its action.

Methods of microscopic observation of bacteria.—Bacteria are examined microscopically directly from the morbid material taken from the body, or from cultures of the microbes got from such material. In conducting these observations a good microscope with a $\frac{1}{12}$ inch objective lens and a substage condenser are required. The preparations are examined, stained or unstained, the latter in what is known as a *hanging drop* preparation to ascertain the size, arrangement, motility, and other peculiarities of the living organisms. When cultures are to be examined this method is an essential part of the process. Stained preparations are used for morbid materials generally. The method of doing this is usually very simple and easy. There are various staining methods each suitable for certain microbes—sometimes double-straining is required for differential processes. The chief staining agents are made from the aniline dyes.

Bacteria as parasites and saprophytes.—Bacteria may be classed as *parasites*, which can obtain pabulum to live and multiply in living animals or plants, and *saprophytes*, which flourish in dead material only. Some bacteria, whilst preferring a parasitic life, may also, under suitable conditions, grow in dead material—these are called *facultative saprophytes*; the germ of gonorrhœa thrives in the mucous membrane of the urethra, but grows very slowly in culture media outside the body.

Terms parasitic and pathogenic not synonymous.—The terms *parasitic* and *pathogenic* are not strictly synonymous. A parasitic organism is not necessarily disease-producing, as we know that the blood of many lower animals harbours animal parasites of various kinds without being affected in any way by them. A pathogenic organism may produce disease without itself entering into the body, as occurs in tetanus and diphtheria, in which the bacteria multiply *in loco*, generate toxins, which affect the system; or, as in a large blood-clot in a wound to which putrefactive organisms have gained access, producing that form of blood-poisoning known as *sapræmia* by the production of toxins, the latter only and not the bacteria entering the system.

Meaning of the term infection.—*Infection* is the access of living virulent pathogenic bacteria to a region of the body where their toxins may act on the tissues. Dead bacteria, such as those of the bacillus tuberculosis, may cause pathogenic effects almost like those of living ones, yet this is not infection, as it cannot be carried from the person inoculated with the dead bacteria to other persons.

Virulence of bacteria.—The virulence of microbes varies enormously. It is possible to increase or lower this virulence in various ways. For instance, one of the septic organisms (*Streptococcus pyogenes*) is often devoid of virulence to rabbits; the injection of large amounts of pure culture has no ill-effects. The virulence can be exalted so that a few of these micrococci can give rise to severe disease. This enhancement of virulence is effected by merely passing the microbe through other animals—one animal being inoculated with a large dose

of the microbe, and the germ recovered from this animal cultivated outside the body passed into another animal, and so on, in a series. It is considered that something like this occurs in nature, for micro-organisms taken directly from a patient are usually more virulent than those cultivated artificially in culture tubes or plates. In some cases these disease-germs are not virulent, and do not endanger life, but in many cases they tend to overwhelm the vital processes by the poisons they produce. In this latter case the medical man attempts to keep the patent alive until the natural powers of getting rid of the germs are brought forward. In general we know but little of the causes which lead to exaltation of virulence under natural conditions. Outbreaks of typhoid fever vary in their intensity, and such variations, whilst they may be due to other causes, such as greater susceptibility as regards age, condition of health, etc., of those attacked, it is probable that modification of virulence is also a factor in these variations.

When a bacterium is in a weakened pathogenic form, it is said to be *attenuated*. We know, for instance, that the vaccine used against small-pox is a weakened culture of the, as yet, undiscovered micro-organism of small-pox. Artificial attenuation of pathogenic bacteria is of great importance in connection with the production of immunity against communicable disease. As a rule the cultivation of a bacterium under slightly disadvantageous circumstances lessens its virulence, and *vice versâ*. Cultivations are frequently attenuated by heat slightly above that most favourable to the growth, or, to a less definite extent, by a temperature slightly below that most suitable for their growth. In all cases the microbe must be capable of producing disease (pathogenic) if infection is to occur, and for this two factors are necessary—the microbe must be virulent, and the host susceptible.

One essential factor of infection is that the toxins of the microbe must act on the tissues of the host. Our skin is frequently crowded with streptococci; our mouth, tonsils and throat harbour various germs, including those of pneumonia, tubercle, diphtheria, etc., but no evil results arise, either because the germs of these diseases do not form toxins or, if formed, these toxins do not reach the tissues. This is not infection; but if any trifling abrasion of the skin or erosion of the throat arises, or a general lowering of resistance to pathogenic organisms occurs from, say, excessive fatigue, prolonged hunger, etc., infection by these organisms may take place.

Universality of bacteria.—Under the circumstances of every-day life, we are all more or less constantly exposed to possible sources of infection. Microbes exist in the air we breathe, in our food, beverages, etc.; they are constantly in the alimentary tract, and on our skins. Yet comparatively few people are affected by them. Hence we conclude that there is some active natural method of resisting the attack

of these disease-germs, and that it is only when these natural means fail us, break down, or are inadequate to withstand attacks of these germs, that infection occurs. This power of resisting the invasion of disease-germs we call *immunity*—it is the antithesis to susceptibility. The *bacillus communis coli* exists normally in the lower intestinal canal, and is perfectly harmless so long as it remains there and the bowel wall is healthy ; but when morbid changes occur in the mucous membrane of the bowel, it exhibits an active tendency to penetrate the wall and become virulent—this is the principal active cause of what we call infective peritonitis, such as may follow attacks of appendicitis.

D.—Immunity.

Cause of recovery from general infective diseases.—Patients recover from general infective diseases caused by microbes by the production of such a degree of immunity as shall suffice to destroy the bacteria causing the disease. Hence the study of immunity is of the utmost importance in connection with the prevention (and in some also the cure) of infective diseases, especially as the best artificial means of doing so are those which imitate or stimulate these natural processes. The most conspicuous example we have of this is in the cure and prevention of diphtheria by the use of its antitoxic serum. The mortality from diphtheria has greatly decreased under the use of this agent, and " contacts " using it sufficiently early are rendered practically immune from the disease for the time being.

Nature makes vigorous efforts to get rid of germs from the blood. If in perfect health, and all the organs and cells are working efficiently, in most cases the germs find themselves in an unconquered soil, and die out without multiplying, or are taken up by the white blood cells.

Meaning of immunity.—By *immunity* then, we mean a condition of the body whereby it resists the development of infectious or morbid processes. Immunity may be acquired or natural. Acquired immunity is that derived from the inoculation of attenuated virus, or the chemical products of infective micro-organisms, or from a previous attack of the same disease, or from a modified form of it such as cow-pox (vaccinia) produced by vaccination against small-pox. The protection afforded by the inoculation of the virus of a disease is also spoken of as *artificial immunity*. Immunity may be transcient or permanent, relative or absolute.

Natural immunity.—*Natural immunity* is that which is inherent in the system when born. It is the natural resistance of the system or tissues to disease. Lower animals are immune from certain diseases of man, and *vice versâ*. There is no absolute standard of immunity, for we know that the reaction to the microbes of infective disease varies from the highest degree of susceptibility, to that of the highest

degree of immunity. For instance, if several animals are inoculated with the same doses of the same culture of an infective bacterium, in one no evil effects are produced, in another only slight reaction occurs, and so on, until we reach one of the series dying of a fatal general infection. Or, an animal may be in state of maximum immunity to a microbe of ordinary virulence, and at the same time intensely susceptible to the same bacterium when its virulence is heightened. Again, the immunity or susceptibility to a given infective microbe is not a definite fixed degree, it varies from time to time and is considerably affected by external and internal conditions, and a study of these conditions is of the greatest concern in the prevention of infective disease. Usually we possess a great degree of immunity to nearly all infective bacteria, and it is only when this immunity becomes reduced by causes which lower the general or local vitality of tissues that infection occurs.

Causes of lowered immunity.—The causes which lower immunity are *local* and *general*. Of the general causes we may mention exposure to cold and wet, impure water, impure air, and defective ventilation, especially when these are conjoined, and still more so if associated with hunger or improper food. They are all potent reducers of immunity, but why they should be so we do not definitely know.

Bad, deficient, or improperly cooked food leading to defective nutrition, intemperate habits, irregular habits as regards meals, sleep and work generally, defective clothing, and idleness, seriously lower immunity. Even temporary loss of nutrition reduces resistance—a long fast, for instance, especially when combined with a long and fatiguing march. *Age* is an important factor in regard to immunity in many infective diseases, and as a general rule the younger the person the less the immunity. Our European soldiers in India, for instance, arrive in this country at an age at which they are specially susceptible to typhoid fever.

Poisons circulating in the blood, whether generated as the result of defective physiological processes in the body, or introduced from without, as occurs in the excessive use of alcohol, lower immunity. Prolonged breathing of impure air also lowers nutrition and resistance to infective diseases.

Amongst the local causes lowering immunity may be mentioned congestion of the throat, and chills giving rise to catarrh of the respiratory passages or of the bowels, which may thus pave the way for the attacks of various microbes.

Acquired immunity.—*Acquired immunity* may be *active* or *passive*. *Active immunity* results from a former attack of an infective disease acquired naturally, or arises from artificial inoculation, so that the person is free from the risk of contracting it again. Of the many

thousands of cases of small-pox one has seen, in only one instance, that of a West African negro sailor, had the disease occurred twice. In most of the infective diseases second attacks are rare. This is not always true, however, as persons have apparently quite recovered from such specific conditions as pulmonary tuberculosis or even constitutional syphilis, and got it again, whilst persons may suffer from septic diseases repeatedly.

Active immunity is only developed slowly and after the inoculation of the toxin, or of the living or dead culture of the infective microbe, and in general a week or longer at least must elapse before the full degree of immunity is produced. In active immunity the person has successfully fought the microbe or its toxins. Passive immunity lasts, as a rule, a comparatively short time, unless the dose of the immunising serum be repeated. In the case of preventive injections of anti-diphtheritic serum, the immunity lasts only a few months. Active immunity is more lasting, though the length of time varies considerably for different diseases. In small-pox and syphilis it may be permanent, but this is not an absolute rule; in typhoid fever it lasts about one and a half years; in pneumonia it is of very short duration.

Passive immunity.—*Passive immunity* is where an animal makes no such fight, but has the serum from an animal previously immunised injected into it—the second animal not being affected at all, locally or generally, by this injection. If affected at all, it is no more so than if the simple sterile serum of the animal (without the anti-toxin) were injected. Such sera are used from the horse to give passive immunity against tetanus and diphtheria. Passive immunity is acquired the moment the serum is injected.

Methods of artificial immunisation.—The most important ways of endowing a person with artificial immunity are:—

(1) Inoculation of the disease, which is now practically never done. It was at one time adopted in small-pox, and even syphilis, but the persons so inoculated sometimes got the disease very severely and even died, whilst in the case of small-pox, vast epidemics were sometimes started from such inoculated persons.

(2) Inoculation with the microbe of the disease in a weakened state. The best example of this is vaccination against small-pox. We see it also in protective inoculation against hydrophobia after the bite of a rabid dog, according to PASTEUR's system. We do not know what the special parasite in either rabies in animals, or hydrophobia in man is (in all probability it is a protozoon), but we know that inoculation of part of the nervous system of infected rabbits immunises man bitten by rabid animals against hydrophobia. In anthrax the disease is prevented in sheep and other animals by the injection of a living culture of the bacillus anthracis weakened by being subjected to a high temperature.

(3) Injections of dead cultures of microbes is now used in the preventive inoculations against typhoid fever, plague, cholera, etc. These cultures are killed by heat and small doses injected subcutaneously. The result is a local inflammatory reaction of varying severity with general symptoms, such as some fever and malaise. When these have passed off, the person has acquired some degree of artificial immunity against the disease, so that he is now able to stand a dose of even the living germ of the disease without as a rule becoming infected.

(4) Injections of extra-cellular toxins of infective bacteria cannot be used in man because of their highly poisonous nature, but they are now largely used in lower animals for the preparation of prophylactic and curative sera, especially in tetanus and diphtheria. For this purpose the horse is used, because it yields a large amount of this serum and is easy to deal with. This principle is worked out as follows. A small quantity by toxin (filtered to remove all living bacteria) is injected subcutaneously into the horse. It excites local inflammation, fever, and malaise, which soon subside. Another slightly larger dose is injected with practically no effect, and so on, until the animal is so resistant that the injection of extremely large doses of the poisonous toxin will produce but slight and temporary evil effects.

Resistance of healthy tissues to action of disease-germs.—Healthy tissues have considerable power to resist the invasions of disease bacteria so long as the latter are not introduced in excessive quantities, and there is little doubt that these microbes are in reality being constantly destroyed in the body in ways that are not yet thoroughly understood. Bacteria are excreted by the kidneys—we know that the bacteria of pyæmia, septecæmia, dysentery and enteric fever, are often found in the urine; the fæces often contain them, and the saliva and sweat glands are credited with some power in eliminating certain bacteria. But of the exact way in which this elimination arises we are still ignorant.

Theories regarding immunity.—Various theories have been advanced to explain the way in which this immunity is acquired. There are two classes of circumstances—the immunity against the microbe, and the immunity to their toxins. If we inject, say, the living microbe of diphtheria and its organic poison into the tissue of a susceptible animal, if the animal lives, the living microbe will grow, multiply and produce more toxin, and the toxin injected will produce its effects at once. If we do the same to an immunised animal, the microbes will die and the toxins have no ill-effects.

Cellular theory of immunity.—What is known as the *cellular theory of phagocytosis* of METCHINKOFF has been elaborated from a knowledge of the habits and life action of the lowest forms of animal life, *amœbæ*, which are represented in the human blood by white blood cells (leucocytes). These unicellular protozoa or amœbæ ingest, digest, and assimilate bacteria found in water. The white blood cells of man do the same in the blood in many diseases. White blood cells have been carefully watched while they digested and completely assimilated bacteria. White blood cells are attracted to the part invaded by bacteria, because these bacteria give off a soluble substance for which the white blood cells have an affinity, and the bacteria become surrounded by a regular zone of them. When this process of devouring bacteria by white blood cells is active, recovery as a rule takes place; but when it fails, the bacteria grow and multiply. In animals with acquired immunity, the white blood cell has gained the power of ingesting bacteria, although, presumably before immunisation unable to do so, and it is considered that acquired immunity is due to the education which white blood cells have gained during the previous attack. Actual living and virulent bacteria are engulfed, digested and assimilated by white blood cells.

This theory is not complete by itself, as it was found that when bacteria were placed so that the white blood cells could not get at them, and the body fluids could, the bacteria often died, and bacteria have been killed by the body fluids (especially the serum of the blood) without any action of white blood corpuscles. This is explained by the theory that bacteria are killed by certain bodies formed or secreted by white blood corpuscles called *alexins*. This theory attributes to the

leucocytes the most important function of defending the body from the attacks of bacteria, a function which is partly chemical and partly phagocytic. This is not the whole explanation however, as we know that it is possible to give rise to a passive immunity, as in the use of anti-diphtheritic serum, (an antitoxin which has no power of killing bacteria. This shows that its action cannot be due to alexins or other germ-killing bodies. There is much left to be done before we can understand the whole processes connected with immunity. We now know that it is possible to produce antitoxins against such highly-organised chemical poisons as those formed in the poison glands of snakes. It is unnecessary here to discuss other complicated theories in explanation of the methods by which immunisation is brought about. We have seen that the white blood cells, and the body fluids when acting together are capable of defending the body from the attacks of bacteria; and that when their defensive power has been lowered by any cause bacteria may get the upper hand and perpetrate their ravages on the system.

Outcome of work and immunity.—The foregoing remarks show that although we are not yet in a position to scientifically demonstrate the forces which operate in the production of immunity, as they are still only imperfectly understood, yet the results obtained so far show that in few directions has the practical application of scientific physiological and pathological knowledge been so satisfactory as regards results. There are several diseases in which we can now bring about a condition of artificial immunity by which we endow the system with a protection against such diseases.

An *antitoxin* is an antidote elaborated by the body to counteract the toxins of bacteria. They are used in the treatment of certain infectious diseases and also to confer immunity against these diseases.

HAFFKINE'S anti-cholera *vaccine* is a sterilised culture of cholera bacillus to give immunity against cholera; and his anti-plague vaccine is a virulent culture of the plague bacillus sterilised by heating it to 158° F.

An antitoxic serum is a fluid that acts on bacterial toxins and is not bactericidal—such a serum is that against diphtheria. YERSIN'S serum is the serum of a horse immunised by injecting a virulent culture of the plague bacillus into a vein of the animal.

A *bactericidal serum* is one that destroys bacteria, but has no effect on toxins. Bacteriologists all over the civilised world, including many experts in India, are constantly engaged in laboratories and in hospitals inquiring into the life-histories of disease-germs and endeavouring to ascertain how best to interfere with their multiplication both outside and inside the human body. They do this by cultivating these germs in various microbe foods, such as gelatine, isinglass, beef broth, peptone, etc., under all sorts of varying conditions of heat, in sterile test tubes and on sterile plates. The germ is first got from the sick person and put into the cultivating medium where it grows. Nearly all disease-germs grow in different ways and have certain microscopical characters by which they may be individually distinguished.

We know a great deal about the life-history of these germs, how they get into the body, how long they take to produce their special disease, how long they will continue to multiply, and when we may expect the patient to get better if he is going to recover.

"Whether a person is going to recover or not from the effects of the growth of disease-germs in his body depends upon how well or how successfully he can manufacture an antidote or corrective to the poison created and poured into his system by the germs. If sufficient of the antidote is made, then the germs are gradually killed and their poison neutralised, followed by gradual recovery of the sick person. If, on the other hand, the germs make so much of the poison, or the patient fails to make sufficient antidote to neutralise the germ poison, then he dies as the result of the disease caused." *

It unfortunately happens that with all possible care and precaution, and every effort at cleanliness and sanitation, general and personal, the germs of disease do sometimes find their way to the blood.

E.—Animal Parasites.

We have hitherto spoken of bacteria as sources of disease. There are also a large number of *animal parasites* which invade the human economy, some giving rise to most dangerous infective diseases through blood infection, others to local maladies of different kinds.

Certain animal parasites may cause grave disease and even death, as we see in untreated grave malarial infection, in kala-azar, filariasis affecting different regions of the body, hydatid of the brain from embryo tape-worms got through the eggs contained in the excreta of dogs, and in other diseases. Some of these parasites invade various internal organs and the blood (malaria and kala-azar) and others the tissue under the skin (guinea-worm). Most of those named are, until got rid of by treatment, permanent parasites of the body. Others attack man only occasionally and under special circumstances ; in these latter we may include such parasites as mosquitoes, bed-bugs, ticks, flies and their larvæ, and leeches. Most parasites of the larger kind reach the bowel and internal organs through water, food, or earth, the eggs or embryos being ingested, or by the embryos attacking man through the skin.

General characters of animal parasites of man.—Parasites are living structures which live and grow on or at the expense of another body called the *host*. In some cases the parasite does no harm, in others it deprives the host of nutriment or produces poisons which injure the host.

* Col. R. H. Firth, *Military Hygiene*, p. 31.

The animal parasites which may inhabit the blood, tissues, or internal organs of man are all characterised by the greater simplicity of their structure as compared with that of the non-parasitic kinds. Most animal parasites invading man exist in two forms—the immature, embryonic or larval form, and the mature form. Many of them undergo a series of metamorphoses or alteruation of generations, before reaching maturity, first by sexual uniou, produciug eggs which give rise to larvæ or embryos which develop into adult forms; or, by a process of budding, give rise to colonies of mature organisms. When man is infected by the fully developed parasite he is the *definitive host;* the *intermediate host* is the animal in which the immature forms are lodged, whilst we speak of the *habitat* as the part of the body of a host in which a parasite or its immature form takes up its abode for the time being.

The chief diseases connected with animal parasites in the human blood in India are—malarial fevers, relapsing fever, and what is known as kala-azar. The parasites of these infections are *protozoa.* Filariæ are also met with in the blood stream giving rise to elephantiasis of the leg, etc., the diseases due to this parasite being embraced under the term *filariasis.*

The subject of malaria is dealt with *in extenso* later on. Amongst other general diseases from animal organisms we may mentiou the following:—*Trypanosomiasis*, or sleeping-sickness, due to an elongated flagellated actively moving animal parasite, which gains access to the blood and lymphatic system through a species of blood-sucking fly (*Glossina palpalis*), and multiplies indefinitely in the blood, giving rise to disorganisation of the nervous system, lymphatic glands, etc., and manifesting itself by fever, headache, torpor, sleepiness, etc. It has so far practically always been fatal. It occurs in a limited area in Central Africa, and occasionally on the West Coast of Africa. Infection is known to be acquired only in regions where the special fly flourishes, along certain rivers and the great lake Victoria Nyanza. We have several diseases in horses and cattle due to a very similar animal parasite of this class ("Surra" in India, *Nagana* in South Africa, for instance), and it was through the investigation of these latter that we acquired a knowledge of the essential cause of sleeping-sickness.

Relapsing fever is another disease associated with the introduction of an animal parasite into the blood, the parasite being probably conveyed to man by the bed bug. In it there is found iu the blood what is known as a *spirochæte*, in the form of a rapidly moving spiral, filamentary animal parasite which gives rise to this fever. The disease is also pathogenic to certain monkeys. These spirochætæ were experimentally introduced into healthy animals by the bite of bugs

taken from infected animals. It is comparable as regards its cause also with the spirillosis of fowls and of South African cattle, in both of which certain species of ticks are the media which communicate the disease.

Different species of *filarial parasites* are occasionally seen in man. The mature forms of these parasites are rarely met with. The sexes of adult forms are distinct; the male is usually smaller than the female and they occupy one or other kind of blood vessels—those of the general circulation, or of the lymphatic system. The mature female is usually a small slender hair-like worm with a club-shaped head. The embryos are about $\frac{1}{75}$ of an inch long and about equal in breadth to the diameter of a red blood corpuscle. The adult worm inhabits the larger lymphatic vessels or lymphatic glands. The embryos gain access to the blood of man through the proboscis of the common culex mosquito *(Culex fatigans)* and also through two or more species of anophelines, whence they make their way to the lymphatic glands. There the sexes unite, develop to maturity, create embryos which are discharged into the lymphatic vessels and then on into the general circulation. In one variety the embryos are formed in the vessels of the surface skin at night

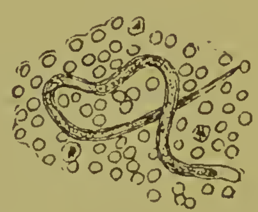


FIG. 64—*Microfilaria bancrofti*, a worm-like parasite of the blood, the parent of which causes elephantiasis, etc. From Major S. P. JAMES, I.M.S., *Malarial Fevers*, 3rd Edition.

only (*Microfilaria bancrofti*); in another variety the filaria are found in the blood only during the day (*Filaria diurna* of MANSON), and in a third it is always present in the peripheral circulation. It is only the first of these that is of importance in this country. This parasite is capable of giving rise to the disease known as chyluria (or milky urine) by invading the lymphatics of the urinary system; to elephantiasis of the legs or scrotum by occupying the lymphatics of these regions, and to a variety of other local conditions.

One should not omit a mention of guinea-worm (*Filaria medinensis*) which in some parts of India is a source of much inefficiency in Native troops. In the Nizam's Dominions one has seen as many as 52 men of one regiment affected with guinea-worm, whilst several in one man was not uncommon, one man having as many as nine in different regions of the body simultaneously. The parasite is communicated to man through drinking water containing the embryo, which develops in a small crustacean (*Cyclop quadricornis*), and is discharged into water and drunk, finding its way from the stomach to the tissues beneath the human skin and there maturing. It is not likely to be a cause of inefficiency on field service, as a residence of some time in the endemic area in which it occurs is usually necessary to its invasion of man.

Animal parasites, like the vegetable microbes of disease, are prone to invade persons in a weakened condition, or in a state of less resistance from any cause—those who are already suffering from disease in some form, or are badly fed, or over-fatigued, the young and the old are specially subject to attacks of parasitic disease. People in good health and physique are, however, often attacked by animal parasites.

Animal parasites of man are often divided into *Ectozoa*, or those which affect the exterior of the body, the term being usually limited to such parasites as affect the skin only—lice, itch-mites, etc., and *Entozoa*, those invading the interior of the body, the term being usually only applied to parasites affecting the intestinal canal.

Skin parasites are usually acquired by contact with those who harbour them, but sometimes they are conveyed through the air, or by contact with infected clothes.

Parasitic skin diseases may be due to animal or vegetable parasites. Of the former the chief are the itch-mite *(Acarus scabiei)* and lice (varieties of Pediculi), of the latter varieties of ring-worm.

Absence of bodily cleanliness and dirty clothes foster the occurrence of parasitic skin diseases, and any excessive prevalence of such disease in a battalion indicates neglect of personal cleanliness or defective personal hygiene in some form.

The chief intestinal parasites with which we are here concerned are round worms and tape-worms. The former is dealt with under a special heading in the section of special diseases. There are various kinds of tape-worms (or cestodes) which may infect the intestinal canal of man. Of these the chief are (1) the beef tape-worm (*Tænia mediocanneluta*), which in the immature form occurs in the muscles of cattle (as many as 300 of these embryos have been found in a pound of beef) whilst in the mature form it occurs in the intestine of man; (2) *Tænia solium*, of which the embryos occurs in the pig, giving rise to the "measles" of pork; man forms the host owing to eating imperfectly cooked measly pork; the mature form occurs in the small intestine of man, but occasionally the immature form is met with in internal organs. All tape-worms may be prevented in man by the thorough cooking of the flesh of animals containing the embryonic form. It should be remembered that the fæces of all persons suffering from intestinal worms contain the ova of these parasites—hence their excreta should be incinerated or buried deeply in the soil. Regarding round worms we may say that water polluted with evacuations containing the ova is one of the most fertile means of propagating these parasites. Animals may be infected by eating the excreta or grass infected by them, and man by eating the vegetables grown on soil manured by such excreta.

Epizootic diseases.—Various animals, both domestic and in the wild state, are subject to infective diseases, some of which are capable of being communicated from these animals to man. Hence it is necessary to adopt measures which will prevent the spread of such diseases in animals, and the measures of prevention are to a large extent similar to those practised in the case of man. The chief epizootic diseases in this country are—anthrax, tuberculosis, tetanus, rabies, foot and mouth disease, rinderpest, plague, glanders, "surra" and filariasis of different kinds.

C.—Disinfection and Disinfectants.

Disinfection in sanitary work is practised for the purpose of destroying the germs of communicable disease which are thrown off by the dejecta, including fæces, vomit, urine, expectoration, skin, etc., of patients suffering from such disease. As these germs are also contained in the clothes and bedding used by infected persons, and find their way to the floors, walls, furniture, carpets, and utensils surrounding the patient, it is obvious that these must also be disinfected. In practical disinfection we have not only to kill the germs themselves, but in some cases also their spores, which are hardier, more resistant and more difficult to destroy.

Disinfectants are agents that destroy the germs of disease, of fermentation, and of putrefaction.

Antiseptics are substances which arrest or weaken the action of germs, microbes or micro-organisms, but do not destroy them. Amongst these we may name corrosive sublimate, carbolic acid, lysol, cyllin, izal, creolin, iodoform, thymol, salicylic acid, formaldehyde, etc.

Deodorants are agents which conceal disagreeable smells; as examples of these we have camphor, various scents—eau-de-cologne, lavender water, etc.

There are three classes of disinfectants—*natural*, *physical* and *chemical*. Amongst the natural disinfectants we may include *fresh air* and *sunlight*. Light and aeration are important aids to the purification of areas that are likely to become contaminated. Their application is general rather than special, but they are undoubtedly efficient auxiliaries against such eminently infective diseases as tuberculosis and cholera. Abundant aeration is useful in that it helps also to dessicate bacteria—moisture is necessary for the preservation of microbic life.

Sunlight.—This is one of the most generally efficient germicides. It destroys bacteria and their spores. This germicidal effect resides in the blue-violet and ultra-violet rays and depends on their intensity. These rays only act on the surfaces exposed to them. Typhoid bacilli are killed by six hours' exposure to the sun, plague bacilli in half an hour, cholera and the common colon bacilli in one hour, and tubercle bacilli in seven hours. Direct sunlight is unfavourable to the growth of pathogenic micro-organisms, none of which survive prolonged exposure to it.

Physical disinfectants.—Amongst the physical disinfectants we have *heat* and *electrolysis*, but as the latter has hitherto played no part in disinfection in this country it will not be further alluded to here.

Heat may be used in the *dry* form, as fire or heated dry air, or in the *moist* form as boiling water or steam.

Fire by actual incineration is the safest of all disinfectants. It gets rid of disease-germs once for all, and, when practical, should be carried out. Fire is of limited use in every day practical disinfection. On a small scale it may be used to destroy the discharges of patients with infectious diseases such as cholera, dysentery, typhoid fever. It is of general applicability in getting rid of dry refuse.

Dry heat.—A temperature of 284° Fahr. continued for three hours is required to destroy all spores. The bacteria themselves are killed at a lower temperature. Fabrics exposed to hot air at this temperature are frequently injured, and it is not therefore much used except for leather or books which would be injured by moisture. The chief effect of drying on microbes is the removal of their natural moisture.

Heated air is not a reliable disinfectant although readily and inexpensively carried out on a large or a small scale. Hot dry air does not easily penetrate the inside of a thick bed or a roll of blankets, which may not, even after prolonged exposure to dry heat, reach the temperature required to kill disease-germs. One has constantly subjected articles to dry heat in an extemporised baker's oven having a hoop-iron or tin framework covered with clay, the articles requiring purification being suspended on bars running across the interior of the oven.

Boiling.—*Boiling* is one of the most common aud readiest methods of disinfection to practise on a small scale. Most microbes are killed by a few minutes' boiling in water, and all are killed by half an hour's boiling. Boiling is particularly recommended for soiled bed-linen and wearing-apparel; all that is necessary is to ensure complete penetration. Penetration is facilitated and the destruction of germs favoured by the introduction of washing soda—a teaspoonful to each quart of water.

Steam.—This is a powerful germicide; it is reliable, rapid and has great penetrating power. By it bacteria are killed instantly and spores in a few minutes. It is best used under pressure.

In a few large towns special apparatus are in use for sterilising articles of clothing by steam under high pressure, and iu recent years in India has been largely used in connection with plague infected clothes. It is very desirable that such an apparatus should be provided in all large cantonments. Disinfection of clothes and bedding in large cantonments is best carried out by some form of steam disinfecting apparatus. The most generally useful are Thresh's and Washington Lyon's, which are simple in actiou and most effectual. There are various other patterns in use.

Current steam.—Articles may be disinfected or sterilised by exposing them to the action of *current* steam (212° F) at the pressure of the air for three hours. A current is necessary to expel the air from the interstices. Exposure for one hour to steam at 212° F. will destroy all pathogenic bacilli and their spores. The penetrating power of moist heat in the form of steam is due to the condensation of the steam as it advances into a cold object, and the formation of a partial vacuum which is at once filled by more steam from behind, and so on. As the steam condenses it parts with its latent heat and raises the temperature of the matter in the vicinity to a high degree.

Large bundles, such as mattresses, pillows, carpets, etc., are best disinfected by steam in a large disinfecting chamber specially constructed for materials of this kind. It usually consists of a receptacle or chamber into which the articles are placed ; the apparatus should permit of being tightly closed and it should be insulated. The wall of the receptacle should be double with an intervening space which can itself be heated by live steam. The outside wall surrounding this space, called the steam jacket, should be insulated to prevent the rapid loss of heat from the interior ; the materials to be disinfected are placed in the inner chamber which is then closed. The steam is admitted to the jacket, thereby raising the temperature of the container. After exposure for the requisite time the steam is turned off from the inner chamber while the jacket is kept hot. Air is then slowly admitted, thereby driving the steam from the material undergoing disinfection and preventing the articles from becoming saturated as a result of condensation.

Apparatus for applying steam under pressure are the same in principle of construction as those for large steam disinfecting appliances. They have to be more strongly made and able to stand a pressure of 15 pounds of steam to the square inch in the chamber, while the space between the inner and outer sheds—the jacket—should bear a pressure of 100 pounds to the square inch. The articles are placed in its interior and the doors closed. The steam is then admitted to the jacket, which is gradually raised to the maximum temperature. In the meantime the air is exhausted from the interior until a pressure of less than one half the atmosphere is obtained. The steam is now allowed to flow gently through the articles to be disinfected, gradually raising the pressure from 15 to 18 pounds to the square inch. The pressure within the chamber is raised and lowered by valves controlling the ingress and egress of the steam, thus imitating the way compression and relaxation are applied to a sponge when attempting to saturate it with fluid. After time has been allowed to permit complete penetration of the materials within, the heat is turned off from the interior in order to facilitate drying, so that the articles are removed quite as dry as they were when placed in the chamber.

Saturated steaming or live steam is equal in power to boiling, the articles being placed directly in the flowing steam, which must be supplied in a quantity sufficient to keep up a temperature to near 212° F.

Chemical disinfectants.—These are of three classes—*gases*, *liquids* and *solids*. The three common gaseous disinfectants in use are sulphur dioxide, formaldehyde and chlorine. Gaseous disinfectants are chiefly used for rooms and other places infected with such diseases as small-pox, measles, plague, and cholera.

Sulphur dioxide.—This gas is heavier than air and therefore diffuses slowly. In the absence of moisture it does not kill germs. Cold water takes up 30 times its volume of the gas forming sulphurous acid which is the real disinfecting agent. Its great advantage lies in its cheapness and the comparative ease with which it can be carried out. It kills all vermin, rats, mice, fleas, mosquitoes, flies, etc., as well as most bacteria. It does not kill spores, hence it is

useless in disinfecting after tetanus. It bleaches vegetable colouring matter, many aniline dyes, acts on most metals and to some extent on linen and cotton fabrics. One pound of sulphur gives 1·15 per cent. of sulphur dioxide gas in 1600 cubic feet of air space. At least 5 per cent. of the gas should be present to kill non-sporing micro-organisms after 24 hours' exposure. To be really effectual at least 4 pounds of sulphur should be burnt for every 1,000 cubic feet of air it is intended to fumigate.

There are many methods of use. The broken up sulphur may be put into an iron pot standing in water. The bulk of the sulphur should be hollowed in the middle, the hollow filled with methylated spirit and then lighted. The placing of powdered sulphur on live coals as is usually done is useless. Dry sulphur dioxide gas, even when concentrated, has no action on germs unless it is combined with watery vapour to form *sulphurous acid gas*. Before commencing the burning process all the doors, windows, chimneys, chinks, or other apertures communicating with the outside air, should be closed. After the sulphur fires within have gone out, the doors and windows should remain closed for 12 hours at least, then opened and currents of air allowed to pass through them for six hours before the room is re-occupied.

The *Clayton apparatus* is the best for giving full effect of sulphur fumigation. The sulphur is burnt in a furnace and the sulphur dioxide gas removed by a centrifugal fan through hoses. Another fan removes the air from the infected room (or place being disinfected) automatically, and passes it back over the burning sulphur. In this way a pressure of the gas can be obtained. It is an excellent arrangement, killing all non-sporing bacteria, rats, mice and insects. It may also be used to disinfect grain in bulk, stores, houses, huts, hospital wards, ships, etc.

Liquid sulphur dioxide.—This is sold in tins with about 20 ounces condensed into a liquid by pressure. The leaden nozzles of several tins are cut simultaneously and quickly inverted into an iron pot, the operator making a speedy exit. Its great disadvantage is its expense.

Sulphur dioxide has been largely superseded by formaldehyde gas. The great disadvantages of most gaseous disinfectants are the degree of concentration of the gas required, the necessity of closing all openings communicating with the outside carefully, and the length of time they take to operate efficiently. Every medical officer knows that the ordinary Indian bungalow is difficult to fumigate thoroughly.

Formaldehyde gas.—This is one of the most generally useful and one of the best general disinfectants we possess. It is a powerful germicide, is not destructive to clothes, and is also a good deodorant. It is one of the few gaseous disinfectants that may be used for disinfecting houses without injuring metals, draperies, clothes, etc. It kills all organisms, whether they are dry or wet. Its defect is its slow diffusion and low penetrating power. To get the full effects of the gas the air must be saturated with it. It kills mosquitoes but does not affect such insects as cockroaches and beetles. For the practical disin-

fection of rooms it is given off in various ways. One of the best is that of heating *paraform.* The drug can be obtained in tabloids of which 2C or 30 are heated in some such receptacle as the "Alformant" over a spirit lamp; the gas diffuses in the room. It is also obtained by boiling formalin solution. Many forms of apparatus are in use such as retorts, autoclaves, etc. THRESH's portable emergency disinfector is a movable box chamber under which a tray of formalin solution is vaporised with a lamp and the gas and steam enter and disinfect articles placed inside.

Formaldehyde gas is one of the most popular disinfecting fumigants at present, and on the whole, one of the most useful and reliable. *Formalin* is a solution of 40 per cent. of formaldehyde gas in water. Formaldehyde gas is liberated from formalin or from tablets of *paraform* by heating in a special lamp.

Chlorine.—Chlorine gas is a powerful disinfectant. It is formed by acting on bleaching powder with strong sulphuric or hydrochloric acid. Its bleaching action on clothes is a great drawback to its use. In practice the gas is made by adding half a pound of pure hydrochloric acid to 2 pounds of chloride of lime.

Solid disinfectants—*Perchloride of mercury.*—Perchloride of mercury is a powerful disinfectant, cheap, and easy to use; but it is very poisonous to man and the solution is colourless.

Perchloride of mercury or corrosive sublimate solution.—The best general strength to use this solution in is 1 to 1,000. When used on a large scale it is best to make up a stock solution consisting of perchloride of mercury 10 pounds, chloride of ammonium $2\frac{1}{2}$ pounds, water 1 gallon, dissolving with gentle heat, stirring in an earthenware pot and adding strong hydrochloric acid, 2 gallons. This makes a concentrated solution of 1 in 3 which should be stored in glass stoppered bottles or stoneware jars. On a small scale we add 140 grains of corrosive sublimate to 3 drachms of strong hydrochloric acid and a gallon of water.

Perchloride of mercury corrodes metals and is poisonous. When using it as a disinfectant we mix with it a little aniline blue, or fuchsin powder to colour it and avoid its being mistaken for water.

Carbolic acid.—Carbolic acid is a poisonous and powerful antiseptic and anti-putrefactive; in sanitary work it is a useful disinfectant, but inferior to cresol. Solution of carbolic acid to be efficacious as a disinfectant should be in a strength of not less than 5 per cent. Strengths weaker than this will not kill bacteria and their spores.

Hence large quantities are required. In this strength it may be used for disinfecting walls and floors; sick-rooms may be screened off from the rest of the house by sheets saturated with the solution hung outside or across the door; all infected linen from the patient may be steeped in such a solution before being removed from the room when the room does not communicate directly with the bath-room; when the room communicates directly with the bath-room the articles are to be at once immersed in the solution contained in a utensil always kept ready at hand in the bath-room.

Very weak solutions of carbolic acid are capable of preventing the multiplication of microbes; they do not kill germs, but rather preserves their activity. Owing also partly to the volatility of carbolic acid which removes it in time, and partly to the peculiarity of its action, another risk is associated with its employment.

The acid may temporarily deprive a microbe of its infective power without permanently abolishing it, the virulent properties may be revived whenever the acid has evaporated. It was for many years used as a germicide, but has of late been largely displaced for disinfection purposes by other chemical agents of greater and more reliable germicidal power.

For purposes of disinfection carbolic acid is used in solutions of 3 to 5 per cent., care being taken to ensure its solution by the use of warm water and agitation. When used in this strength it gives satisfactory results in the disinfection of excreta, articles of clothing, furniture, leather and metal articles, and in the disinfection of walls and floors of houses. Amongst its other disadvantages are its high price, even when the commercial or crude acid is used, as compared with other efficient germicidal agents. When used it has to be thoroughly mixed with the material to be disinfected so that it is brought into intimate contact with them.

Carbolic acid lotion 1 per cent. keeps off mosquitoes and relieves their bites; 2 per cent. lotion disinfects the hands, and artificial dentures overnight.

Many of the patent disinfecting fluids contain chiefly cresols and a small quantity of carbolic acid. Carbolic acid, in combination with various other agents and mixed with some colouring material, such as carmine, are extensively sold and used as disinfecting powders. Such powders are practically useless as disinfectants.

Cresol.—*Cresol* is a product obtained by the fractional distillation of crude carbolic acid. There are three different kinds of cresol, but usually a mixture of them is used. Mixtures of cresols with soaps form emulsions.

Saponified cresol.—This is a powerful disinfectant, three times more so than ordinary carbolic acid; a 1 per cent. solution kills all germs and for ordinary disinfection a strength 1 to 160 is sufficient. Saponified cresol is now largely used in India, and is one of the cheapest and most valuable general disinfectants we possess for human

excreta. The strength we use it in is one ounce to eight pints. In this strength it prevents the multiplication of disease-germs; it is a deodorant, and is disliked by flies.

Lysol.—This agent contains about 51 per cent. of cresols in combination with potash neutral soaps. It is a brown oily liquid forming with water a soapy liquid. It has about the same effect on germs as saponified cresol. It is most useful for disinfecting the hands. Its action is like that of carbolic acid, but it is less poisonous and more actively disinfectant. Its disinfecting properties are intensified in hot water. For disinfection of wounds it is used in a 1 per cent. solution in warm water. It has also a powerful cleansing effect.

Izal.—*Izal* is an emulsion containing 40 per cent of carbolic acid compounds (phenaloids). It is used as a disinfectant and antiseptic (1 part in 200 of water). It destroys bacteria.

Cyllin.—*Cyllin* is derived from the carbolic acid group of disinfectants. It is a proprietary agent and one of the most generally useful disinfectants for this country. It is non-poisonous, forming a white emulsion with water and is a deodorising germ-killer. It is 20 times as strong as carbolic acid as a disinfectant. It is used as a lotion for wounds in a strength of 1 to 200.

Jeyes' Fluid.—This contains 20 per cent. of cresols, with a little carbolic acid and soap. It is a dark brown thick liquid forming a white emulsion with water. It is a useful household disinfectant and is largely used. It is used as a disinfectant in 1 or 2 per cent. strength in water.

Permanganate of potash.—This salt readily gives up its oxygen to organic matter and then becomes quite useless as a disinfectant in the presence of an excess of such matter Its application is chiefly in the disinfection of wells and tanks and domestic supplies of drinking water when the latter is impure. Enough should be added to the water to give it a pink tinge after it has acted half an hour. It is also useful in washing cooking utensils. Permanganate of potassium is only a real disinfectant when in 5 per cent. solution.

Chloride of lime.—This is popularly known as *bleaching powder*. It destroys and bleaches clothes fabrics. Its best use is for scrubbing infected floors and woodwork and disinfecting excreta. As a disinfectant a solution of 0·5 per cent strength is necessary. It is a powerful oxidising agent.

Lime solution.—This is useful, cheap, and to some extent efficient. Quicklime kills germs and destroys organic matter. It may be freely applied to stables, out-houses and other buildings after they have been infected. Also for mixing with excreta. On the whole it cannot be relied on to kill disease-germs.

Slaked lime.—When fresh, slaked lime absorbs sulphuretted hydrogen and offensive gases, such as carbon compounds of ammonia. It is but a feeble disinfectant. Its chief use is in white-washing walls and occasionally in helping to purify the impure water of certain wells (see p. 118). It may be laid in offensive drains, or over accumulations of filth to remove foul smell.

Disinfecting powders.—One has no hesitation in condemning all the patent disinfecting powders, whether of carbolic acid or other chemical agents, as quite useless, if not worse, as they merely conceal foul odours without killing disease-germs. Such powders are very extensively used as disinfectants in India, but have practically no effect as disinfectants.

There is no perfect disinfectant.—A perfect chemical disinfectant has yet to be discovered. Such a disinfectant should be stable and not lose its germicidal power when brought into contact with the materials to be disinfected. It should be destructive to bacteria and the lower forms of animal life. It should be cheap, easy to get, and easily used, and in using it to the tissues it should not damage them. Because no single agent at present known answers all these requirements, several have to be used for different purposes. Whatever disinfectant is chosen it should be remembered that its addition to a fluid to be disinfected causes dilution; *e.g.*, a pint of carbolic acid solution 1 in 20 or 5 per cent. added to a pint of fæces or urine results in a quart of mixture containing only 1 to 40 or 2½ per cent. of the carbolic acid; the same remarks apply to all other liquid and gaseous disinfectants.

Most of the disinfectants enumerated are too expensive for use on a large scale in Indian cantonments and on field service, and as a matter of fact, have no special advantages over the cheaper preparations such as crude commercial carbolic acid, the cresols, and perchloride of mercury solution.

Except in well organised cantonments in which the sanitary arrangements are under the control of a special sanitary officer, it is advisable to avoid the use of complicated apparatus in the form of pumps and sprays for using liquid disinfectants. Coolies to whom these apparatus have to be entrusted, rapidly put them out of working order. The only exception to this is the use of the hand siphon spray used for gardens or a foot-pump spray. Usually a few buckets or half casks with hand mugs or wooden ladles, ordinary sweeper's brooms, or bundle of dried grass tied at the end of a pole, may be used for walls, floors, and similar surfaces.

Disinfection in infectious disease.—In the case of all infectious diseases communicable through the air, excreta, or through insects, the patients should be isolated. The room in which a case of infectious disease is to be placed should be large, airy and well-lighted. Carpets, curtains, drapery, upholstery of all kinds should be removed—a few articles of furniture that may be disinfected at the end of the illness may be permitted. After the room is once occupied by the patient nothing should leave it that is not disinfected. Communication with other rooms should as far as practicable be shut off. A sheet or blanket soaked in a 1—1,000 perchloride of mercury solution, or a 1—20 carbolic acid solution, should be suspended on a line at a few feet from any used door communicating with other rooms in the house. The bedcovers should be of washable material. A couple of thin mattresses are better than one with a water-proof sheet between them. Iron bedsteads with woven wire springs are comfortable. If possible the room should communicate with the bath-room and in the latter are to be placed vessels to receive all articles to be disinfected, and all the disinfectants required. The linen of the bed and patient should be frequently changed. If the patient is placed in a room, all possible means to prevent the spread of infection must be rigidly adopted. Dishes carrying food, containers for water, medicine glasses, spoons, knives, forks, etc., should not leave the room except in a disinfectant, and for this purpose boiling water is best. Infected feeding and cooking utensils should be boiled for 15 minutes.

Towels, clothing, and bed linen generally, from the infected room should be at once placed in a tub or other suitable receptacle kept in the bath-room and containing 5 per cent. solution of carbolic acid, lysol, or creolin, or 2 per cent. of saponified cresol. In the absence of disinfectants they may be thrown into vessels containing boiling water. In no case should such articles be thrown about the room in corners, under beds, or otherwise secreted.

Waste-water from the sick-room may be disinfected by the addition of corrosive sublimate (1—1000), carbolic acid (5 per cent), saponified cresol (1 per cent.), lysol (1 per cent.) or creolin (2 per cent.). The stock solution of corrosive sublimate advised on p. 428 is useful for this purpose.

Discharges from the sick, soiled infected rags, etc., should be received into vessels containing enough of some strong disinfectant solution such as saponified cresol, commercial carbolic acid, or perchloride of mercury. When these disinfectants are not available then sawdust, dry earth or lime may be used, the excreta being at once incinerated. A requisite to the disinfection of excreta is the thorough mixture of the agent with all parts of the material to be disinfected. When the material is liquid this is easy, but where more or less solid it is necessary to add a sufficient amount of water to render the disinfectant thoroughly miscible with the excreta. The best agents are saponified cresol (1 per cent.), carbolic acid (5 per cent.), creolin (2 per cent.), lysol (1 per cent.), izal (1 per cent.). Emanations from the skin should be prevented by the application of some weak antiseptic, such as carbolic oil 1 to 100. Infected clothing should be allowed to soak in disinfecting solutions of proper strength for at least an hour, preferably for two hours

During the illness the dusting and sweeping of the room is to be forbidden. All surfaces including furniture should be wiped with cloths moistened in 1—1,000 solution of corrosive sublimate, or a 5 per cent. solution of carbolic acid, but the smell of the latter is disagreeable to the patient. Care should be taken to reach all corners and out of the way places. If a carpet is in the room it must be daily cleaned with a brush or broom soaked in a disinfectant; if no carpet the floor should be daily wiped with a disinfectant solution, or the floor may be sprinkled with a layer of sawdust or tea leaves saturated with a disinfectant, and after brooming, the sweepings incinerated.

The possibility of reinfecting material that has been disinfected should be borne in mind. The device adopted in the disinfecting apparatus of some of our large Indian municipalities illustrate this. The plant is divided into two parts that do not communicate, except through the disinfecting chamber. The infected materials are received in one end of the building, loaded upon cars which are pushed into the disinfecting chamber, and the door closed. The disinfection having been completed, the articles are removed by other persons at the other end of the chamber which projects within a part of the building intended for the reception of disinfected articles only. Those employed in the two sides of the building do not come into contact with one another when on duty.

Hands.—Those in attendance on cases of infectious disease should be specially careful about the disinfection of their hands. In consequence of the peculiarity of the structure of the skin—the thick epidermis, with many ridges and furrows, the finger-nails, the spaces at the root of the nails, and the crevices at the margins—disinfection of the hands is rendered difficult, although their thick skin permits stronger disinfecting solutions being used. Ordinarily the hands should be thoroughly washed in soap and water, a fairly stiff brush being used. The space at the bed of the nail should be first cleaned with a nail-cleaner and a good brushing. This is followed by the use of boiled (and cooled) sterilised water, then washed in a 1—500 solution of biniodide of mercury or corrosive sublimate, and finally again in sterile water. If corrosive sublimate or biniodide solution in this strength irritates, a 1 per cent. solution of lysol, or 2 per cent. of creolin, or 5 per cent. carbolic acid may be used. Thorough brushing with soap and hot water and subsequent washing in 2 per cent. lysol or cyllin solution will, however, in most cases, remove infection.

A patient recovering from any infectious disease, such as small pox, retains in the skin for some length of time a certain degree of infectivity. The skin should be thoroughly cleansed by means of soap and warm water, the water used as hot as can be comfortably borne, and finally the soap removed by boiled water which has been permitted to cool to a temperature that can be safely applied. The skin should now be further washed in a 5 per cent. solution of carbolic acid or a 1—1,000 of corrosive sublimate. In those with a delicate skin solutions of half this strength should be used.

Disinfection of rooms.—At the termination of an illness the method of disinfection varies in different places. Under ordinary circumstances the following is recommended. If the room is not very clean, if it contain carpets, curtains, draperies, etc., it is well to give it a preliminary disinfection, which to some extent may prevent infection in those who subsequently give it a more thorough cleaning. The windows are closed and sealed by caulking around the sides with strips of cotton wool or old cotton clothes torn into strips, or by pasting over the crevices strips of some adhesive paper, or by ordinary putty. Sheets moistened in solution of formaldehyde or other disinfectant may be thrown over chairs or suspended from ropes running across the room, the room being closed for twenty-four hours. Where this preliminary disinfection is not carried out and the room is to be at once disinfected, the windows and doors are to be sealed as above. Those engaged should preferably wear rubber goloshes, and long washable overcoats or dusting smocks closed from neck to feet. Gaseous fumigation may be carried out with sulphur dioxide gas or formaldehyde gas in the manner previously described (pp. 427-429).

In disinfecting huts in regimental bazars and followers' lines one of the first things to do is to light a large fire in the neighbourhood and into it throw all old rags, all articles used by the patient that cannot be properly disinfected, and all rubbish found. In some cases it is advisable also to remove the tiles or thatch to allow the sunlight to get at the interior of the hut or room. All infected old clothes, straw, grass or bamboo or cocoanut mats should be wrapped in a sheet saturated with disinfectant solution, or in a water-proof, thrown on to the fire, and burnt in the compound.

After fumigation in cantonments where there is a proper steam disinfector, the mattresses, pillows, cushions, and all bulky articles are put into air-tight bags or waterproofs and removed to the disinfecting station. If a carpet has been in use it is sprinkled or sprayed on both sides with a 1—20 carbolic acid solution (or solution of one of the cresol disinfectants), rolled and placed on an air-tight receptacle, in which it is removed with the other articles.

The walls should be sprayed, scrubbed, or mopped with a 1—500 solution of corrosive sublimate, or 5 per cent. solution of carbolic acid, or 5 per cent. solution of creolin or lysol, 2 per cent. saponified cresol, or 2½ per cent. solution of formaldehyde.

The best form of spray for this purpose is the ordinary foot-pump spray used for spraying flowers, with a short rubber tube and a fine rose nozzle. Walls may also be disinfected by scrubbing with one of the above-named solutions. After disinfection the walls should be scraped and re-limewashed. After thorough disinfection and cleansing of the barrack or hut, free ventilation and the admission of as much sunlight as possible are important auxiliaries in getting rid of infection.

Latrines.—If latrines are initially well made, kept in complete repair, and properly worked, they should not need disinfection. During epidemics of disease communicable through human excreta, however, it is in all cases advisable to disinfect them.

It is occasionally necessary to disinfect *cesspits* and *damp, slimy, muddy places.* Sulphuric acid, 1 in 250 or 4 ounces to 4 gallons, is probably the best substance to use in these circumstances. Another excellent disinfectant for this purpose is chloride of lime when of sufficient strength (4 per cent.). Two parts of milk of lime to 10 parts of the material to be disinfected is much less useful, but often the only agent available. Urine may be disinfected with a 2 per cent. solution of lysol, cyllin, or izal; 5 per cent. of carbolic acid, or 1 per cent. saponified cresol, or 5 per cent. of formalin.

Incinerators for hospitals.—Every hospital in cantonments should be provided with some form of incinerator which can at least deal with the excreta of all infectious diseases cases. Small incinerators of the Cook-Young or other pattern may be inexpensively erected in almost any hospital compound and worked without being a nuisance. Portable metal night-soil destructors for dealing with small quantities (up to 20 gallons in the 24 hours) are easily made or procured.

Sputum, spit or expectoration.—When sputum is dry or likely to become dry, as on cloths, pocket handkerchiefs, or Japanese paper (recommended by many), burning is the safest and most convenient method of destroying the germs they contain. Those suffering from diseases communicated through the sputa should use a non-metallic vessel containing a 5 per cent. solution of carbolic acid, izal, lysol, creolin, or a 2 per cent. solution of saponified cresol. Corrosive sublimate is not a good disinfectant for sputa. Spittoons are easier to clean if the disinfectant solution they should contain has in it an alkali; this alkali should not be incompatible with the disinfectant. All disinfected sputa should be incinerated.

Disinfection of food.—All salads, celery, tomatoes, cress, and fruit may be immersed for half an hour in 3 per cent. of tartaric acid and afterwards washed in sterile water, or washed in 5 per cent. formalin

solution, which is harmless. Where reliable disinfection of such articles under responsible supervision is not obtainable, they should be altogether eschewed at periods of filth-borne epidemic disease, or only used when properly cooked.

Clothes.—The disinfection of all infected clothes is most important, especially in the case of small-pox and the eruptive fevers generally; the contagia adhere specially to woollen articles and may be thus readily transported and disseminated. The clothes of infected sick persons should never be sent to *dhobies* before thorough disinfection.

Clothing may be disinfected by (1) boiling for half an hour, or (2) complete immersion in corrosive sublimate solution 1 to 1,000 for an hour. Such articles as blankets, quilts, mattresses, pillows and carpets, are best disinfected in a steam disinfector, or soaked thoroughly in perchloride of mercury solution 1—1,000 for an hour, preferably for two hours, and then dried in the sun. Practically all clothes may be disinfected by soaking in 5 per cent. formalin solution and then washing. When the articles would be damaged by boiling they should be put into a suitable disinfecting chamber where such is available.

Woodwork should be scrubbed with perchloride of mercury solution (1 to 500) for half an hour, or saponified cresol (2 per cent), or lysol (2 per cent.) solution. Bedsteads may be sprayed and washed with 1—500 perchloride of mercury solution, a 5 per cent. hot carbolic acid solution, or 2 per cent. saponified cresol solution.

Earthenware articles should be washed with corrosive sublimate solution (1-1000).

Stables should be sprayed from roof to floor inclusive with 1—500 perchloride of mercury, or 5 per cent. of carbolic acid, creolin, or formalin, or 2 per cent. of saponified cresol. The walls should then be scraped and white-washed. All the loose articles in it should be dealt with as stated under their headings.

Railway carriages may be disinfected by formaldehyde gas or sulphur dioxide as recommended for rooms, but all parts of interior of the carriage should be sprayed with a 1—500 perchloride of mercury, or 1 in 20 carbolic acid solution, or 2 per cent. of saponified cresol; cushions should be wiped with 5 per cent. carbolic or 2 per cent. saponified cresol solution, and curtains soaked for a few hours in it.

Wheeled vehicles drawn by horses or otherwise may be fumigated by being run into a shed and fumigated with sulphur dioxide or formaldehyde vapour. All loose upholstery should be removed and treated separately, the rest of the interior being then dealt with as in the case of the furniture of an infected room, washed with 5 per cent. carbolic, lysol, or formalin solution, 2 per cent. saponified cresol solution, or 1—500 of perchloride of mercury.

Tents may be disinfected by saturating with 1—500 perchloride of mercury solution, or 5 per cent. carbolic or formalin solution, then spread out in the sun to dry, being turned every few hours. The inner and outer flies should be dealt with separately.

Disinfection of dead bodies.—When a person has died of communicable disease the body should be encased in one or more sheets saturated with a 1 in 20 carbolic acid, or 1 in 500 corrosive sublimate solution, or one of the cresol solutions, and be cremated or buried as early as possible. If any discharges are likely to occur from the body it should rest on sawdust saturated with a disinfectant solution, or on a layer of lime, or dry earth, the latter also saturated with a disinfectant.

For the disinfection of *carcases of animals* dead of bacterial disease, destruction by fire is the best method of dealing with them, but it is rarely practicable. They are usually buried in a deep pit of sufficient size, the carcase being thrown on to quicklime which agent should also be thrown upon and all round them. The abdominal and thoracic cavities should first be opened so that the lime can reach these regions. With large animals such as camels, horses, cattle and donkeys, it is advisable in all cases to eviscerate them first and fill the interior of the cavities with lime, the viscera being thrown into the pits.

Chief Diseases of Troops in Peace and Frontier Warfare and their Prevention.

General Remarks on Fevers.

Nature of fever or pyrexia.—Fever is a complex morbid process, the most characteristic indication of which is a rise of temperature above the normal. It is attended with acceleration of the pulse and breathing, thirst, loss of or decreased appetite, and often disturbance of digestion. There are also perverted tissue changes as shown by alterations of the secretions which may be completely arrested or diminished in quantity, and changed in quality; especially is this the case with the urine which is lessened in quantity and darker than normal, and there is increased oxidation. From the retention in the blood of abnormal products of metabolism, and of the waste-products of normal metabolism, other symptoms are often caused, such as malaise, depression, headache, sleeplessness and delirium. When fever is continued wasting occurs, partly as the result of the increased oxidation processes and partly from other causes.

The average normal temperature of the adult is 98·4° F.; in health it may vary from this a little more than a degree (from 97·8° F. to 99·5° F.). It is slightly raised after meals and by exertion. The daily minimum temperature occurs between 2 A.M and 5 A.M., and the daily maximum between 4 and 6 in the evening. The average difference between maximum and minimum is 1·2° F.

While we do not completely understand the whole of the processes in operation during fever, there are certain points in connection with it more or less generally recognised. The normal temperature of the body depends upon the production of heat or *thermogenesis*, which chiefly takes place in the muscles and larger glands of the body, such as the liver; and upon heat-loss or *thermolysis*, which occurs

chiefly from the skin and lungs. The production of heat is controlled by nerves arising from certain nerve centres in the innermost part of the cerebrum ; the heat loss is probably under the control of the central nervous system in the medulla oblongata.* It is also highly probable that there is a part of the cerebrum which has the function of keeping up a balance between heat-production and heat-loss (thermotaxis), this probably existing in the surface of the brain.

Heat-regulation, heat-production and heat-loss, may one or all be disturbed in fever. and it is assumed that in the infectious fevers at least, the toxins manufactured by microbes enter the blood and affect the nerve centres ; but fever may spring from disease conditions operating directly on these nerve centres. We know that in uninfected surgical wounds, if the discharges are absorbed fever arises, and that the same may arise in injury of certain nerve centres from falls or blows without any external injury.

In infectious fevers the disturbance of the heat-regulating centres of the nervous system is probably caused in most cases by the poisonous products of the specific microbe of the disease. There is also, through excessive heat, increased waste of tissues, to which is added lessened excretion. There is likewise an accumulation within the blood of poisonous materials from the germs, and also from tissue waste. The liver and kidneys carry out their functions as eliminators of waste material defectively. The excessive heat production, together with diminished loss, go on so long as toxins continue to be manufactured and circulated in the blood. It is the disparity between heat-production and heat-loss at the beginning of many fevers that gives rise to shivering fits.

As disease-germs multiply, they create poisons called *toxins* which produce the symptoms of the disease from which the patient is suffering—one of the principal effects is *fever* with which is associated headache, nausea, or vomiting and a hot dry skin. They not only produce toxins but after a time *anti-toxins*, which help to neutralise the harmful effects of the toxins, prevent the germs multiplying any further, and may eventually kill them. This only occurs as a rule after the germs have continued in the living body for some time. Frequently the number of germs originally introduced into the body is so great and the toxins are so rapidly produced in large and overwhelming quantities, that they kill the patient before these anti-toxins are formed. This occurs in very severe typhoid fever when the patient dies during the first week, in cholera when the patient dies it may be in the first two or three hours without mainfesting the usual characteristic symptoms of the disease, and in septicæmic plague. Fever may, however, occur in the absence of microbes as when febrin firment is absorbed during non-bacterial inflammations. It is possible also that certain chemical products absorbed as the result of perverted metabolic processes in the body, or from poisonous proteids in the alimentary tract, may likewise produce fever.

Degrees of fever —A temperature of from 100·4° F. to 101·2° F. is *slight fever* : a temperature of from 101·3° F., to 102·2° F. in the morning and 103° F. in the evening is *moderate fever*, and one of from 103° F. to 104° F. in the morning and of 105° F. in the evening is *high* or severe *fever*. When the temperature rises to 106° F. in the morning and 107° F. in the evening, it is called *hyperpyrexia*, and such a temperature if at all lasting is as a rule dangerous to life. Besides these we speak of *collapse temperature*, 92 to 96° F., *subnormal temperature*, 96 to 97·5° F. Practically all fevers begin with malaise, disinclination for mental or physical exertion, headache, pains in the limbs and back, followed by a feeling of being hot, frequent pulse, coated tongue, loss of appetite, scanty and high coloured urine, thirst and other symptoms already mentioned. A *remittent fever* is one, the course of which is interrupted once or repeatedly by a marked decline in temperature, but not reaching

* The *medulla oblongata* is a small but very important part of the nervous system situated between the brain above and the spinal cord below, and continuous with both of these. It contains several of the most vital nerve centres, such as those of breathing and regulation of the action of the heat.

the normal, and followed by a renewed exacerbation ; in it the difference between the morning and evening temperature is more than 1° F. *An intermittent fever* is one in the course of which a complete intermission takes place once or repeatedly ; that is to say, in the progress of the case the temperature becomes normal (or even subnormal), remains normal for an appreciable time of greater or less duration, and subsequently rises to about its previous level. Usually the fever lasts for only a period of the day, there being a freedom from fever during the rest of the day. *A continued fever* is one in which the temperature pursues an uninterrupted course, without sudden variation from beginning to end ; the diurnal variation does not exceed 1·8° F. ; the first rise may be sudden or gradual, there may be steady maintenance of a maximum or continuous increase ; there may be gradual or sudden final lowering of temperature, but there is not a decided fall and a renewed rise during the progress of the disease. *A specific fever* is an essential fever due to a specific pathogenetic agent—typhoid fever, plague, and small-pox for examples.

Stages of fevers.—The course of acute *infectious fevers*, especially those associated with eruptions, are divided up as follows :—

(1) *Stage of incubation*—from the time of infection to the commencement of the phenomena of the disease.

(2) *Prodromal stage* or *stage of invasion*—from the beginning of the fever to the breaking out of the eruption.

(3) *Eruptive stage.*

(4) *Stage of desquamation* or defervescence.

During almost all non-eruptive febrile diseases, the fever is marked by three stages :—(1) The time during which the temperature continues to rise ; (2) the *acme* (or fastigium), or period of little change in the temperature which is usually high ; and (3), the *period of decreasing temperature* (or defervescence) The disease may terminate rapidly in a few hours—this is by *crisis*, or it may decrease slowly and extend over several days, which is known as *lysis*

All infectious fevers run a more or less typical course, and the temperature is to be taken at regular intervals during the whole time fever is present. This is recorded on a *temperature chart* which at once shows the nature of the *fever curve*, which in many of these fevers is fairly characteristic. In practically all cases where fever exists the temperature varies during the day ; in the morning there is a moderate decrease (remission), in the evening an increase (exacerbation).

Chills.—If the body temperature rises very suddenly while the radiation of heat is lessened by contraction of the blood vessels of the skin, the patient has a sensation of being cold which manifests itself by involuntary shivering, chattering of the teeth, and shaking of the entire body. A chill, rigor, or *shivering fit* appears at the beginning of many acute infectious diseases—pneumonia, plague and influenza, or there may be repeated chills at regular intervals (malaria, septic diseases, tuberculosis, etc.).

In taking the temperature a self-registering thermometer is used, the highest point of a little rod of mercury in the tube of the glass rod indicating the temperature, which is shown by the figures and horizontal lines on the thermometer. *Minute* thermometers are useful for this purpose and usually accurate.

The state of the pulse.—The pulse (see p. 146) is felt by placing the finger, usually the index finger, upon the radial artery a little above and to the outer part of the front of the wrist. It is counted for ¼ or ½ a minute, and multiplied by 4 or 2 to give the rate per minute. We at the same time feel whether it is regular or

irregular, disappears under pressure of the finger (compressible) or not, whether it is small and hard (wiry), full and strong, weak, or intermittent. The full value of the condition of the pulse as a sign of disease is only obtained by experienced medical men after many years of practice.

All infectious fevers may assume what is called the *typhoid state*, which is always dangerous. *Typhoid state* is a phrase used by medical men to indicate a low condition of the body which comes on in very serious illnesses, and is generally associated with a decline of the previously more acute symptoms; there is a rapid, soft and compressible pulse; dry, brown, trembling tongue, which the patient puts out with difficulty; a collection of dried mucus and bacteria (*sordes*) around the teeth and lips; great muscular prostration, as shown by trembling of the hands and twitching of the tendons; a semi-comatose state with the eyes open, but the patient not seeing; an apathetic condition, picking at the bed clothes, muttering delirium, and a tendency to slip downwards towards the foot of the bed. The typhoid state may come on in all severe forms of fever lasting any length of time, and is typically seen in severe forms of small-pox, typhoid fever and pneumonia.

Hectic fever.—This is due to chronic toxœmia or blood poisoning where septic toxins are regularly absorbed, as in the chronic pus-formation occurring in the cavities of the lungs in the third stage of tuberculosis of the lungs. There is a regular evening rise of the temperature, followed by night sweats which tend to produce gradual reduction of strength.

Malarial Fevers of India.

Synonyms.—Malaria, Paludism, Marsh Fever, Jungle Fever, Periodic Fever, Paroxysmal Fever, Ague, Coast Fever, etc.

The term *malaria* (It. *mala*, bad, *aria*, air) is used to include a class of diseases which occur both endemically and epidemically, and in which the symptoms, causes and treatment exhibit much similarity. The main group of malarial diseases are the malarial fevers, which are types of fever due to invasion of the red corpuscles of the blood by different forms of malarial parasites conveyed from man to man by certain species of mosquitoes (anophelines), and are characterised by—paroxysmal intermittent fever, which has a cold, hot and a sweating stage, anæmia and enlargement of the spleen; pigment in the blood, deposition of pigment in internal organs; with a tendency to relapses; and finally, if the paroxysms continue, to the production of a specific cachexia. The term *malaria* is also applied to the special causes of malarial diseases and to the combination of conditions that bring these causes into operation. Malarial diseases are essentially local or endemic, but under certain conditions become epidemic. There are periods of increased and decreased intensity in the endemic areas.

Prevalence.—If we exclude the malarial statistics of our large public hospitals (which are so small that in the question of the general statistics of malaria in India they may be neglected), the only figures we can rely on are those published in the Annual Reports of the Sanitary Commissioner with the Government of India. From these we conclude that on an average about 20 per cent. of our Army in India suffers from malaria every year.

We have no statistics showing the malarial rate in the civil population in India, the nearest approach we have to it is the statement that about 5,000,000 people die annually from "fevers," of whom it has been roughly estimated that 20 to 25 per cent. succumb directly or indirectly from malaria. If the malarial fever rate of

the civil population is the same as that in the Army in India, there would be at least 60 millions of cases a year. The probability is that in the rural population poorly housed and worse fed, the proportion is much higher, and that there is in reality something like 80 millions of cases of malaria a year in the civil population. From personal experience one knows that the malaria of military cantonments is always less than that of the neighbouring civil community. At present, however, we are not in a position to estimate within many millions the amount of malaria in this country. Probably about four-fifths of malaria of India is found in the population of villages and probably not more than one-tenth of this number ever get quinine. Our troops are, of course, better housed and fed, have good hospitals and proper medical attendance, and are better kept generally than the civil population, hence the proportion of malarial cases and mortality from malarial fevers is considerably less.

The following table gives the quinquennial admission rates per 1,000 of strength in the Native Army for the periods stated :—

1879-83.	1884-88.	1889-98.	1899-1903.	1904-08.
662	451	341	305	228

In 1907 there were 10,662 admissions among European troops for malaria, and in 1908, 16,824, and for the same years in Native troops 22,603 and 33,438 respectively.

The following table gives the relative incidence of malarial fevers to other diseases in the Native Army during the period 1891—1905 :—

	Admission rates for 1,000 of strength.						Actual admissions.				
Year.	Intermittent.	Remittent.	S. C. Fever.	Influenza.	Enteric Fever.	Intermittent, Remittent, simple continued fever. Influenza, and Enteric Fever combined.	Dengue.	Cerebro-Spinal Fever.	Malta Fever.	Relapsing Fever.	Dengue, Cerebro-Spinal, Malta and Relapsing Fevers combined.
1891-1900	346	15	35	7	24	427	199	2	3	...	204
1901	293	6	24	9	13	345	...	1	5	...	...
1902	247	7	14	2	17	287	298	1	8	1	308
1903	243	4	18	3	20	288	303	...	9	...	312
1904	174	3	24	5	20	226	439	...	6	...	445
1905	111	2	48	14	16	191	415	2	4	...	421

The above table shows the marked diminution of malarial fever cases during the quinquennium 1900-1905.

It is considered by several authorities that some of our recorded cases of sunstroke are deaths due to intense malarial poisoning. One's personal experience does not bear out this statement. Of our European troops there is roughly about 650 men always in hospital, 14 of these being due to enteric. We can accept the general statement that the malaria admission-rate in the tropics is about one-fifth of strength. In some places, of course, it is only nominal, but in others this is made up for by having an admission rate of from 100 to 200 per cent., each man on an average being admitted once or even twice.

In former years some cases of simple continued fever were included as cases of malaria, but whilst a certain number of these were probably enteric fever, Malta fever, "sand-fly" fever and other pyrexial disturbances, there is no doubt that some were likewise cases of malarial infection.

The average death-rate in civil native children is from 20 to 30 per 1,000; this is largely due to malarial infection. The force of this remark will be seen later.

The incidence of malarial fevers in nearly all campaigns prependerates *facile princeps*. This is easily accounted for—latent malarial infections in men acquired at their stations, initial malarial infection *en route* to the front, or actually at the front. These malarial fevers affect the Native Army as much as the British.

Chief malarious regions.—The intensely malarious nature of the Himalayan Terais, Assam, Manipur, the Bhutan Frontier, and the Lower Chin Hills is well known; and the foot of the hills along practically all our Frontier is perniciously malarious. For many years the Gurkha battalion quartered at Shillong sent a detachment to Sabankatta, Udulgeri, and Daranga for three months—January, February and March, yearly. Usually every man had been under treatment more than once for malarial fever, or dysentery, or both. In April 1901, of the 51 men of the 43rd Gurkha Rifles, who returned to Shillong from this out-post duty, 39 had enlarged spleens half filling the abdomen; and in others the enlargement was considerable; in two it only was perceptibly enlarged, whilst there were only two without any splenic enlargement. In 1902 an almost identical result occurred. This was represented strongly to the Lieutenant-General Commanding the Eastern Command, with the result that a local police levy now carry on this duty. These out-posts were on the lower slopes of the Bhutan Hills.

Deep ravines in malarious places may be very deadly. One can recall a place named Taungboo, situated in a pass about 7 miles from Mandalay, in which we held a block-house, guarded by 40 men. In April 1887, one was sent out to report on this place and examine the men. They had been there for seven weeks. On the day of my inquiry 37 of 40 were suffering from one or other form of malarial fever—there were not enough effectives for the sentries required. One recommended the daily use of quinine prophylactically, and that the men of this out-post should be changed weekly; this was done with excellent results. The climate and physical conditions in Burmah during the hot weather are extremely adverse to

active operations in the field, the extensive swamps, the dense jungle, heavy rainfall, and the consequent prevalence of malarial fevers, not only greatly hampers the movements of troops, but absolutely incapacitates them from further service, if subjected to prolonged exposure. In the swampy country very short distances are got over and the fatigue is enormously increased by the difficulties of getting transport along. In May and June heat apoplexy is common. The enormous low-lying alluvial tracts, great jungles and the great unhealthiness of the land below and on the slopes of the Burma hills are well known.

A glance at the various medical statistical tables of our Indian campaigns shows that malarial fevers in every instance play the predominating part in giving rise to inefficiency, and this holds good in both our European and Native troops. In many of the cases which occur in our troops and followers on field service, infection was acquired in cantonment, the disease occurring as the result of recent inoculation by mosquitoes, or as relapses from former infection—(*Vide* APPENDIX).

CONTRIBUTORY CAUSES OF MALARIA.

Meteorological relations of malaria.—*Temperature*—This has an important bearing on malaria. A temperature of 60° F. is the limit at which malarial fevers occur. Those regions in which this degree of heat is not attained by the mean summer temperature remain exempt from malarial fevers. In endemic malarious areas during the winter mosquitoes are driven into houses, huts, stables, and then the malarial parasites perish. In the spring again in many parts of India the mosquitoes become re-infected from cases of relapses. Great falls of temperature in malarious places are important in respect of their being associated with relapses from chills, the latter operating by lowering the physiological resistance and then permitting latent malarial parasites to multiply.

Rainfall.—The amount of rainfall, and the period over which the rainy season continues, have an important influence on the prevalence and distribution of malaria in India. In general terms it may be said that rainfall conduces to the production of malaria because it is favourable to the development of larvæ of anophelines.

Alternate saturation and dessication of the soil is especially favourable to the extension of malaria, just as a thoroughly, permanently permeated soil, or a completely dry soil, is unfavourable to malaria. The banks of the Ganges, Indus, and Brahmaputra periodically overflow their banks, and malaria appears in the tracts affected shortly after the subsidence of the overflow. This leads us to infer what actually is the case—that mosquitoes flourish in the shallow pools and puddles left in the beds of the river after the subsidence, and do not thrive in great collections of rapidly flowing water where they would be washed away in the torrents or eaten by fish. When the pools left are flooded, washed out and converted into deeper collections of water, their evolution from ova to imago is greatly interfered with. During a dry period following rapidly upon heavy rains or freshets, malarial outbreaks are severe and frequent. This phenomenon is constant and pronounced.

Winds.—The diffusion of malaria by winds occurs only over very limited distances, as hills, trees and other obstacles protect houses to leeward of malarial places. This is explained by the known habits of anophelines, who are weak fliers, and in winds secrete themselves in trees, brushwood and bushes, and even in grass, and are easily hindered in this flight by obstacles.

Moisture.—The typical malarious locality is low and marshy, or in the vicinity of rivers, lakes and large accumulations of stagnant water. Some regions in India almost free from malaria in the hottest part of the dry season become very

malarious shortly after the beginning of the rains, and this malarial intensity becomes greater during the autumn. Moisture is essential to the development of the eggs and larvæ of anophelines. The period following the overflowing of rivers and inundation of the surrounding country is specially malarious. This latter condition is imitated artificially over large tracts in this country by the irrigation of rice and other fields. Small swamps and the collections of water seen round or near villages are responsible for much of the malaria met with in districts.

Subsoil water level in relation to malaria.—As a general rule it may be said that a persistently low ground water level, say 15 to 20 feet, is unfavourable to malaria, that a persistently high level, say 3 to 5 feet, fosters malaria, and that a level which fluctuates is most malarious. This opinion is forced upon us from the general literature of the subject and experience of malaria throughout India.

Configuration of the ground.—This is highly important as it affects the manner in which surface water is disposed of. Hollows and ditches and all excavations without outlets, given other conditions, favour malaria; *per contra*, elevated sites, if they permit of rapid drainage, are unfavourable.

Altitude as affecting malaria.—Whilst malaria is seldom met with at great altitudes, the old, hard and fast rule that malaria did not occur by initial infection beyond 4,000 feet in India is certainly incorrect. The general statement holds good, however, that the higher we ascend, the less the chances of a place being malarious, because the physical, telluric and climatic conditions become more unfavourable to the development of mosquitoes. There are few instances in which initial malaria (fresh infections) occur beyond 6,500 feet. Malarial fevers are usually most severe and persistent in low-lying coast districts, deltas of large rivers, and flat alluvial plains.

Personal Predisposing Causes.

Age.—Malaria attacks all ages, but most frequently children under 10 years. The very old and very young (infants under three months) are less frequently affected with malaria in endemic districts. Old people have probably acquired a certain degree of immunity to the parasite, very young infants have not had time to get thoroughly saturated with parasites. Children between 6 months and 10 years of age are especially prone to infection and re-infection, which go on in endemic areas during the whole of this period. While adult natives in an endemic malarious locality may be comparatively free from malarial infection, a large percentage of the young children suffer to a greater or less extent, though always to a less extent than new arrivals from non-malarious places.

Race.—Native adults resident in malarious places are less liable to malarial infection than Europeans. They acquire more or less immunity early in life. The blood of a large percentage of native children is inhabited by the parasites of malaria. Anophelines to a large extent receive their infection from native children. Newly arrived Europeans in malarious localities in India are specially liable to malarial infection; they are also specially attractive to mosquitoes. Europeans newly arriving in malarious places suffer more from severe acute forms of malarial fever than the indigenous people, whereas acclimatised persons are more frequent victims to the chronic forms; if exposed to malarial influences for some time without suffering from malarial fever, they acquire a certain small degree of immunity. Under no circumstances does the European in malarious places acquire complete immunity or undergo complete acclimatisation. Eurasians are more subject to malaria in endemic malarial areas than natives, in this susceptibility following their European progenitors. This observation was originally made by Ranald Martin and has been repeated by many experienced medical officers in India. Apart from constitutional peculiarities, individual predisposition to malarial infection is met with, which may be in part explained by the fact that some people are more attractive to mosquitoes than others.

Occupation.—This is a factor predisposing to malarial infection only in so so far as it exposes to the attacks of infected anophelines. Those employed in

excavating soil in malarious places, in building railway lines, roads, etc., and camping on the sites where these excavations take place, are especially predisposed, because they dwell in the midst of the breeding grounds of anophelines.

State of health.—All conditions enfeebling the body even temporarily, such as common colds, remaining in wet clothes, a wetting in the rain, severe bodily fatigue, excessive mental work, inadequate amount of sleep, excesses of any kind, excitement, defective and insufficient diet, drug habits, minor illnesses of all kinds, injuries acute and chronic, surgical operations and defective dwellings, increase the susceptibility to malarial infection. Hence the advisability of using quinine under all circumstances liable to enfeeble the resistance to malarial infection. Similarly all bodily and mental depressions tend in some way to revive the vitalities of latent malarial parasites and bring about relapses; hence the necessity of completely eradicating malarial parasites once infection has occurred by a prolonged course of quinine. There is no doubt that persons in good health are capable of throwing off a mild infection of malaria without presenting any clinical manifestations of such infection. This is constantly happening in malarious districts even without quinine prophylaxis.

Defective hygiene.—Defective hygienic conditions are important predisposing causes. Houses that are small, damp, dark, ill-ventilated and dirty, are specially favoured by mosquitoes. The small damp thatch or bamboo huts without windows of most villages are examples. Large houses with lofty rooms, good ventilation, abundance of light and all sanitary needs, considerably reduce the possibility of infection. The enormous outbreaks of malarial fevers that occur amongst coolies on canal irrigation works are largely fostered by the unwholesome conditions under which they live—huddled together in small *chappar* huts, scantily clothed, with meagre food of small nutritive value, and exposed to night chills. This is very prevalent combination of conditions amongst large gangs of workmen in this country.

Previous attacks of malaria.—Previous attacks of malaria predispose to further attacks from slight causes. A simple catarrh, indigestion, a hard day's work, a cold bath, and even change to a colder and more salubrious locality, may bring on an attack. Most of such cases are in all probability relapses and not new infections. When any length of time has elapsed since leaving the malarious place, as on the voyage home, after arrival in Europe, or in a non-malarious hill station, and an attack occurs, this is, in practically all such cases, a relapse. Absolute and permanent freedom from relapses cannot be assured for a year or more of freedom from the last malarial infection. Occasionally relapses are stimulated by "water cures." Men sometimes get their first relapses at Carlsbad after leaving this country—the baths in some way reinvigorating latent malarial parasites.

Time of day.—It is well recognised that the risk of malarial infection are greater during the night, which is now explained by the infection through anophelines usually occurring at that time, as these insects are mainly nocturnal in their attacks on man.

Immunity.—It would appear that there is no hereditary immunity, or absolute acquired immunity against malarial infection. The parasite may remain in the system for long periods; latent parasites are of frequent occurrence in adults of endemic districts. It is possible that the parasite of malaria is capable of producing immune bodies in the system for self-defence, and that for this reason the blood plasma and white blood cells are helpless to deal with them In quinine we possess a drug which gives us a relative immunity similar to that which the native in malarious places acquires. It is preferable to this natural partial immu-

nity, because in the latter the person harbouring malarial parasites (latent infection) may remain a source of infection long after convalescence. It is stated that dark-skinned races, living in malarious regions, possess a relative immunity to malarial infection. The explanation is that it is due to an acquired immunity, the result of frequent infections in childhood. The relative immunity of inhabitants of endemic areas is acquired and not inherited. We find in such areas a high percentage of the children harbouring malarial parasites in their blood, and in ordinary years comparatively few adults with parasites. Prolonged residence in malarial districts gives rise in those who survive malarial infections to a degree of relative immunity. There is no doubt that recurring attacks ultimately render the individual less prone to infection. The explanation is that that the malarial toxins bring about some changes in the human economy which render it less liable to further attacks. In other words, we get a condition in which after repeated attacks of malarial fever which have been less and less severe, there is established a spontaneous and more or less permanent cure. This immunity may endure for years, but any condition lowering the vitality or lessening the resisting power is liable to remove it. The same often arises by going to a new locality.

In all probability the explanation as to acquired immunity is a much more complex and obscure problem than these statements would appear to indicate, and the factor or factors entering into its occurrence are as yet but imperfectly understood and call for investigation.

Theories of Malarial Infection.

It is obvious that until the manner in which malarial infection was brought about in human beings, it was not possible to formulate any rational basis for the general prophylaxis of malaria.

An enormous amount of work was done after the discovery of malarial parasites in human blood with the view to solve this highly important question, and this work has resulted in a solution of the problem by a complete demonstration of the relationship of the anopheline cycle to malarial parasites. The views held anterior to the discovery of this relationship are in many ways deserving of our attention; they were chiefly connected with the conveyance of malaria to man (1) through air and (2) water.

Air theory of malarial infection.—The theory that the "poison," "miasm," "germs" or "parasites" of malaria emanate from the soil to the air, and gain access to the human economy through the respiratory tract, is the oldest, and has throughout the history of malaria from ancient to comparatively modern times, been the most popular. The air of malarious regions has been repeatedly investigated with the view to discovering the presence of the malarious parasites. Such observations in modern times have invariably been negative.

Water theory of malarial infection.—To prove that water can convey malaria it would be necessary to export the malaria-conveying water from the malarious district to an assured non-malarious district, and allow persons, who are known never to have suffered from malaria and at the same time do not harbour malarial parasites in their blood, to drink such water. If at the end of the maximum period of incubation of malarial fevers such persons did not suffer from pyrexial phenomena associated with malarial parasites in their blood, the proof would fail. A successful experiment of this kind has never been carried out; on the other hand such experiments have on several occasions been carried out with negative results.

Mosquito-malaria hypothesis.—In 1894 Manson definitely formulated a mosquito-malaria hypothesis, his argument being that as the protozoal organism of malaria is a parasite, to maintain its existence as a species it must pass from host to host, that it must at one phase of its existence live outside the body of man. Further, that as the flagellated body of the male malarial parasite does not come into existence until the blood has left the blood vessels and is outside the human body, he concluded that the flagellated body was the first phase of the life of the parasite outside man. As the parasite in the blood of man is intra-corpuscular, and consequently incapable of leaving the body spontaneously, he conceived the view that it was received by some blood-sucking insect common in the regions where malaria was endemic. He believed this insect to be some particular genus of

mosquito. In 1894, he suggested to RONALD ROSS that mosquitoes took gametocytes (p. 455) into their body, and that gametocytes are the means by which mosquitoes may be infected.

Ross in 1895 demonstrated the fact that when malignant tertian blood containing crescents is ingested by a mosquito, a large proportion of the crescents rapidly proceed to form microgametes and to throw out flagella. He demonstrated that in particular species of mosquitoes fed on malarial blood, living and growing malarial parasites containing melanin are to be found embedded in the stomach wall of the insects. In 1897 he also demonstrated that if a particular kind of mosquito be fed on the blood of birds containing a malaria-like parasite (Proteosoma), the parasite enters the stomach wall of the mosquito, grows and sporulates there, that the resulting sporozoites (p. 456) enter the salivary glands of the insect, and that the insect is then able to infect other birds. He showed that only particular species of mosquitoes can carry this special avian malarial parasite in this way, and that the particular species of mosquito was not efficient as regards another blood parasite of birds, *viz.*, Halteridium, or as regards the malarial parasite of man. Ross was the first to prove both by analogy and observation that the phase of the malarial parasite outside the body of man is passed in particular species of mosquitoes, and inferred that the parasite is transferred from man to man by the mosquito. The method of the discovery of the communicability of malaria from man to man by anophelines is one of the most profoundly interesting subjects in the whole history of medicine, and has done more than any other discovery to stimulate inquiry into the various animal parasites communicable to man through insects and otherwise. Infected anophelines if exported from endemic malarial localities to non-endemic places, and made to bite non-immune persons, produce malarial fever. The experiment of transporting malaria-infected anophelines from endemic malarial foci to non-malarious places, and inoculating people who have never been out of these non-malarious places, has more than once been carried out successfully. It has been definitely shown that (1) the extinction of anophelines in a malarial district practically removes malarial infection; and (2) that the rigid use of mosquito nets or dwelling in mosquito-proof houses, without any other prophylactic measures, is capable of preventing malaria in the most virulent malarial districts.

It is now satisfactorily proved that uninhabited regions, although they may be densely populated by anophelines, are free from risks as regards malarial infection. "Infected mosquitoes occur only in the immediate neighbourhood of settlements of infected individuals." Members of exploring expeditions have often remained free from malarial disease so long as they have been in regions remote from such settlements. Sailors who do not go ashore in endemic malarial places escape malarial fever because they have not been bitten by malaria-infected mosquitoes. The long known view that exposure in the evening, at night, and in the early morning, in endemic malarious places is dangerous, is now fully explained by the nocturnal habits of anophelines. From their structure, vast numbers, and ability to fly, mosquitoes are endowed with potentialities which facilitate their dissemination of disease.

We may now state that practically all the main facts connected with the epidemiology of malarial fevers are explained satisfactorily by the dissemination of malarial infection through certain anophelines. No solid proof is yet to hand to show that malarial fevers are produced in any other definite way. The cases cited of people acquiring malarial fever the day they arrive in a reputedly malarious place cannot bear scientific examination; in such instances it is possible that malarial infection was due to previous mosquito bites of which the patient was unconscious, or that they were relapses, or that these cases were some other form of fever. The discovery of the fact that anophelines convey malaria was not made in a day; it was not the result of any sudden inspiration, nor does it depend on any superficial considerations. Each link of the chain of evidence has been carefully examined, and the conclusion is firmly based on numbers of experiments and observations by many investigators and trained experts with scientific minds. There is still some difficulty in persuading many intelligent officials that the malaria-carrying power of mosquitoes lies at the foundation of our known anti-malarial measures. One is constantly meeting military and civilian officers who express incredulity regarding the relationship between malaria and anophelines.

Factors required to produce malaria.—(1) *Anopheline mosquitoes.*—As far as we know no other forms of mosquitoes, or other insects, can act as carriers, though we have still to admit the possibility of such an occurrence until the subject is worked out.

(2) The present or recent existence of cases of malarial fever—including relapses and cases of malarial infection acquired in other regions in persons who have come to the district.

(3) *External physical conditions*—climate, moisture, temperature, and season favouring the attacks of the mosquito, suitable for its infection, and for further development of the sexual form of the malarial parasite.

(4) Susceptibility of the mosquito and of the individual bitten to infection.*

In the absence of any of these conditions an outbreak of malaria is, as far as we know at present, impossible. There are many places where anophelines exist without malaria; others in which there is no malaria at particular seasons, because the conditions at these seasons are unfavourable to the development of the mature forms of the parasite, or the gnats do not bite.

General characters of mosquitoes.—Mosquitoes are two-winged flies (Diptera) of the family *Culicidæ*. "Mosquitoes, as in other six-footed flies, are provided with a head, thorax and abdomen. The head bears the mouth-parts drawn out into a long penetrating proboscis, which latter is often as long, or even longer, than the whole body. The head, thorax and body of all culex mosquitoes are covered with distinctive scales; but in the *Anophelinæ* these may only occur on the head, the thorax and abdomen being hairy."

Metamorphosis of mosquitoes.—All mosquitoes undergo a complete metamorphosis, that is, there is an active, growing and feeding stage, the *larva*; a non-growing stage, the *pupa*, during which stage the larva is transformed into the active flying sexual adult—the mosquito.

Anophelines, the only known carriers of malaria.—There is no evidence at present that other mosquitoes than anophelines can act as hosts of malarial parasites. We cannot definitely assert that some species of Culex, and even some of the genus Stegomyia, which are so universally represented in this country, may not be carriers of malaria: we know positively that some species of Culex cannot carry malaria, and none so far have been shown to be malaria-carriers.

Number of known species of mosquito.—About 800 mosquitoes have been classified and described. Comparatively few only of these are connected with diseases. The vast majority are wild or sylvan mosquitoes, and, as would be expected, their habits are not so well known as the domestic kinds. Up to the present altogether about 135 species of Anophelina, including 40 species in India, have been described.

* THEYER in ALLBUTT and ROLLESTON'S *System of Medicine*, Vol. II, Part II, p. 243.

Differentiation between *Culicinæ* and *Anophelinæ*.—The following table will enable us to distinguish the ova, larvæ, and adults of *Culicinæ* and *Anophelinæ*, it being understood that the characteristics given are those of the sub-families, and in no sense specific :—

Culicinæ.	*Anophelinæ.*
Eggs.—Laid in rafts, individual eggs bottle or cartridge-shaped. Found in artificial collections of water which are often dirty.	Laid singly and then forming triangles or other geometrical figures ; in water the individual eggs are boat-shaped, each with ends like the raised prow and stem of a boat, and ribbed laterally (*float cells* containing air); the ribs looking like oars.

Fig. 65.—Egg of Anopheline.

Fig. 66.—Egg raft and eggs of Culex.

Fig. 67.—Eggs of Stegomyia.

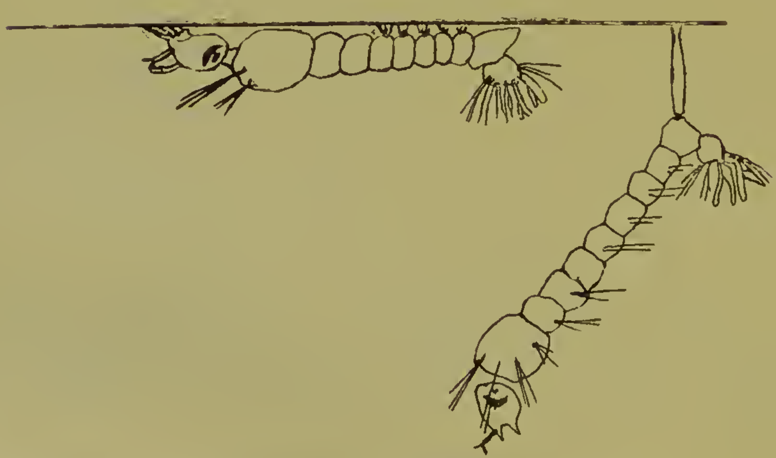


Fig. 68.—Larvæ of an Anopheline (left) and Culex (right).

Culicinæ.	*Anophelinæ.*
	The eggs sometimes occur separately and are then found touching particles of leaves or vegetable debris. The eggs are found in natural or terrestrial collections of water.
Larvæ.—Long breathing tube (siphon) near tail, and a large number of air vessels which distribute air to all tissues of the body. It is attached to water by surface tension. If the surface of the water is covered with oil the larvæ sink. They float head downwards. Their normal position is at the surface, but they wriggle to the bottom on being disturbed. Culex larvæ cannot live at the bottom	Have no breathing tube. They breathe through two apertures at the back of 8th abdominal segment of the body. They float flat by surface tension with their palmate hairs. When disturbed they skate backwards. They are found in terrestrial waters. A few species may be found in artificial collections of water, *e.g.*, *Nys. stephensi* in chatties and wells.

Fig 69.—Showing distinction between resting attitude of an Anopheline (left) and Culex (right).

Culicinæ.	*Anophelinæ.*
of water, there they would soon die. When changing their skins they can float flat, but never to the same extent as anopheline larvæ. They are found in artificial collections of water—tubs, cisterns, chatties, kerosine oil tins, pots, pans, broken bottles, etc.	
Adult mosquito.—Short *palpi* in female. They *sit flat* or only with a slight angle to the surface on which they are resting. The *wings* are *plain* and not spotted. The body is unshapely and somewhat hunch-backed. The thorax is large. They are grey, sombre, or dusky coloured.	Long *palpi* in female. Angular position to surface on which resting—tends to stand on its head as it were—the proboscis, head and body being at an angle to the wall or surface on which resting. The *wings are spotted.* The body is graceful and shapely, the head tapers into the proboscis. If the anterior border of the wing has three or four spots it is certainly an anopheline.
Breeding places.—Tubs, ditches, garden cisterns, drains for rain-water, etc. In temperate climates they often choose terrestrial waters—they do not do so in the tropics.	Terrestrial waters—river, stream, lakes, pools, ponds, all collections of water, rain-water runnels, etc.

The method of identifying mosquitoes is comparatively easy after the basis upon which they are classified is thoroughly understood. A few hours spent with some one who has acquired the habit of identifying and grouping mosquitoes into genera, and collected eggs and larvæ for demonstration, is more profitable to the uninitiated than weeks of perusal of descriptions and studying plates and diagrams.

Rate of multiplication of mosquitoes.—Mosquitoes are very rapid breeders. All the species of anophelines known in this country pass through several generations during the period from the beginning of the rains to the setting in of the cold weather. It has recently been calculated by Ficalbi that from a mother stem two hundred millions of mosquitoes may be produced in four months. During the breeding season each succeeding generation of mosquitoes becomes considerably larger in numbers than the preceding one, and when we consider the rapidity of their multiplication and that this is in geometrical progression, there is obviously an enormous advantage gained in lessening the number of generations.

Length of life of mosquitoes.—Formerly it was believed that mosquitoes lived only for five or six days. Now we know that they may live for months. *Stegomyia calopus* can certainly live for five months. Anophelines have been kept alive in captivity for 155 days. There are many mosquitoes known to hibernate both as adults and as larvæ throughout the winter. We cannot at present say

what the average length of life of the mosquito in Nature is. In captivity we remove them from the dangers of their natural enemies, birds, inclement weather, high winds, excessive rain, etc., although they must be affected by the artificial conditions of life in captivity.

Anophelines can remain alive in huts for two months and possibly longer. Subsequent to the drying up of all their breeding places, it is found that the number of anophelines does not decrease to any material extent for several weeks, but if this drying up continues, their numbers gradually diminish; species may, however, be caught in the neighbourhood for two months (or even more) afterwards.

Flight of anophelines.—The flight of anophelines—the most delicate of the *Culicidæ*—is limited. This flight is said to be generally about half a mile. This being so, the extermination of all breeding places within an area of half a mile radius should eliminate malaria. Immigration of mosquitoes from other areas into cantonments and places where anti-malarial operations continue has been urged against such measures. There is evidence to show that such importation in endemic malarial areas is constantly in progress, but under normal circumstances immigration and emigration balance one another, so that this factor alone should not affect the question of anti-mosquito measures. In a recent investigation of the malaria in a large district one found both winged anophelines and their larvæ in every plains station within half a mile of cantonments, and in most stations in the heart of cantonments themselves.

It may be stated that up to the present time the distance anophelines can fly is a question that has not definitely been settled. The probability is that they seldom fly over half a mile, and they cannot fly even this distance if there are any barriers to penetrate, such as trees, jungle, etc. It is a mistake to cut down jungle indiscriminately in the belief that it harbours mosquitoes. This may give anophelines an inlet from infected bazars or village huts, or from breeding grounds. On the other hand long grass, jungle, and brushwood may foster anophelines by giving them rest and shelter between their breeding places and human habitations.

Time mosquitoes bite.—The majority of Indian mosquitoes prefer biting at night. During the day they obscure themselves amongst shrubs and bushes, in dark corners of native huts, tents, barracks and houses. Some favour dark objects, dark clothing being particularly attractive. The specially domestic kinds such as the *Culex fatigans*, *Stegomyia calopus*, and *S. asiatica*, are not often seen remote from habitations, but sometimes may be found in jungles. Occasionally some of the wild or sylvan mosquitoes, contrary to their usual habits, are found in houses, huts, and habitations generally.

Local irritation from mosquito bites.—The irritation caused by a mosquito bite has nothing to do with malaria. The irritation is caused by the fluid injected by the mosquito from the small cavities in the body of the mosquito which contain enzymes or ferments of bacteria; this causes congestion of the part and thus admits of a full supply of food to the surface. The first thing the mosquito does is to insert its proboscis into the skin; the next is to project its poison, which she does before drawing blood. Persons living in mosquito-ridden places acquire an

immunity to this poison, which does not in them produce any irritation; just as some men in this country who are constantly gathering honey-combs from jungles become immune to stings of bees. It is well known that some people possess a natural immunity to this poison. The absence of irritation is therefore not a sign of exemption from malarial infection—it may disguise the fact when malarial infection has occurred. We also know that the bite of malaria-bearing anophelines is associated with less discomfort, pain, and annoyance, than that of either of the other two chief genera of mosquitoes in this country—Culex and Stegomyia. The irritation caused is less in inhabitants of mosquito places. This is possibly explained by immunisation against the bacterial enzymes injected acquired by residence in the area, and is of no importance in the study of malaria.

Capture of adult anophelines.—Adult mosquitoes when at rest may be captured in test tubes or small bottles by placing the mouths over them. Personally one has made more rapid captures by using small butterfly nets 8 to 12 inches in diameter, with a bamboo or cane circular rim at the top and a short handle. When required for simply counting the relative numbers of different species of anophelines or for dissection for sporozoite rate, this is a fairly rapid method of collecting anophelines.

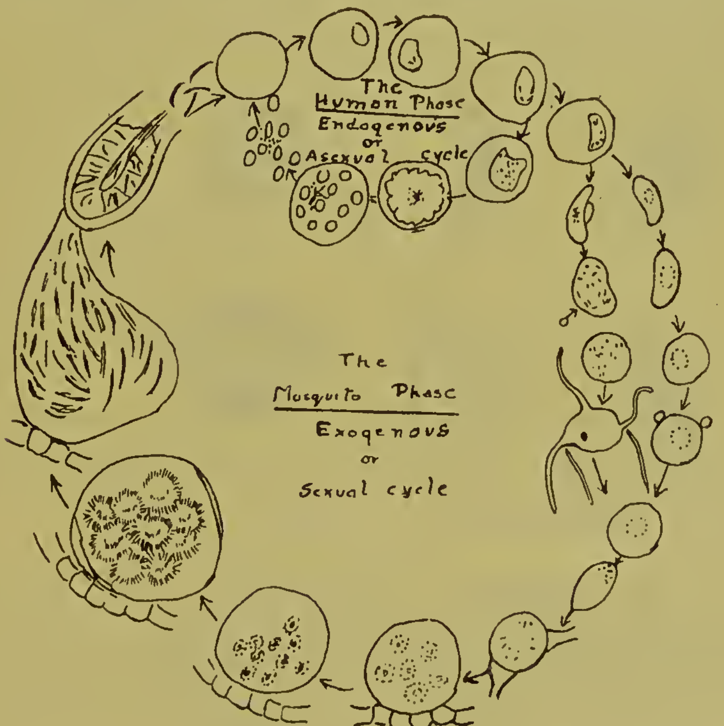
All Culicidæ are aquatic in their larval and pupal stages, and live in water. They swim and dive by means of paddles and feed on water organisms. They cannot breathe under water. In a week or more the pupa is formed from the larva. Larvæ vary from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch in length, the latter being their length when full grown. Their colour varies; most are brown, yellow, or greenish. Anopheline larvæ are specially found under cover of grass and weeds in water, and are not often seen in the open, except in stagnant waters. The smaller and moderate sized collections of water are more favoured by anophelines for oviposition than the larger. Recently one found that a comparatively shallow pool connected with a hydrant in the Native Infantry lines at Agra swarmed with *Myz. culicifacies* and *Ps. rossi* larvæ. The greatest numbers of malaria-bearing larvæ have always been found in moderate sized pools. It may be here remarked that of two similar tanks fairly adjacent to one another, for some unknown reason one will contain many anopheline larvæ and the other none. Larvæ have numerous enemies and are often covered with parasites. Anopheline larvæ have never been found by me in large irrigation canals and their branches when these were in *pukka* conduits free from grass and weeds; they were, however, always found in *katcha* irrigation channels, and in the *katcha* waste channels from *pukka* irrigation canals. The absence of larvæ from *pukka* canals is explained by the periodical shutting off of the water or by the rapid flow in a channel usually devoid of grass and vegetation. Sometimes a large tank may be searched around its whole circumference without finding a single anopheline larva, and then one reaches a small shallow branch of it or a small channel draining into it, which will contain myriads. The drying shallow parts are specially favoured by them. A very light wind, one only just sufficient to cause a barely visible ripple on the surface of the water, will often cause anopheline larvæ to drift to leeward. Time will often be saved by at once inspecting the leeward side of large collections of water.

We have much to learn regarding the habits of anophelines before we can effect their eradication from even limited endemic malarial districts. Observations in such districts will have to be carried out for some years before we can solve many of the unknown problems of to-day that harass the anti-malarial sanitarian. One of the chief directions in which profitable study and observation might be carried on is in the method of æstivation and hibernation of anophelines. It is during these periods of hiding that their numbers are comparatively few, and were we to know where to attack them in the larval and adult stages during the non-breeding seasons, we should certainly

be able to materially diminish the numbers appearing in the breeding season. In places where that season continues all the year round the task is still more difficult. Destruction of hibernating mosquitoes is most useful because if not carried out, being fecundated, the females will deposit their ova as soon as the meteorological and telluric conditions are favourable for her doing so.

THE PARASITES OF MALARIA.

The parasites belong to the sub-kingdom PROTOZOA or unicellular organisms, and to the phylum Sporozoa. There are three species met with in India, possibly four. In each species the parasites invade, occupy and lead to the destruction of the red cells, in doing so creating toxins, and pigment (melanin); they multiply indefinitely in the blood by simultaneous sporulation which occurs at regular intervals of two or three days, producing attacks of fever. They are carried from man to man by certain species of anopheline mosquitoes. Quinine has a specific action on the parasites, killing all those it comes into contact with, when it is in a sufficient state of concentration in the blood.



- Diagram of the Asexual and Sexual cycles of the Malaria Parasite (C. W. Daniels.)

The *life-history of all malarial parasites* is as follows: The youngest of them occur as small amœboid bodies (a *parasites* is as follows :—The yood cells. Each cf these young forms consists ofmœbulæ) on or in the red blotoplasm. They

reach maturity in two (simple and malignant tertian parasite) or three (quartan parasite) days, and in doing so convert the hæmoglobin into melanin. They during their development may form (1) a number of spores or (2) gametocytes. In those that form spores the nucleus divides into a varying number of segments, each segment gathering some of the protoplasm around it and becoming a spore. When finally mature, the body ruptures and sets free its spores, together with melanin and toxins, into the blood plasma. The spores attack fresh corpuscles, and the malanin is eaten up by the white blood cells. The rupture of all red cells containing spores occurs more or less simultaneously. This is what is known as the *asexual* or *fever-producing cycle* of malarial parasites. In the young forms which develop into *gametocytes* the nucleus does not divide. These gametocytes are the sexual forms, male and female, of malarial parasites. They do not undergo any further change under ordinary circumstances in the blood of man, but are there ready to be taken in by anophelines. When they reach the stomach of the mosquito they undertake sexual functions. They set themselves free from the red cells in which they are enclosed. The male gametocyte in from 10 to 30 minutes throws out three or more active mobile filaments or flagella called *microgametes*. These break away from the microgametocytes, wander about, and finally enter the female gametocyte. This fertilises the female, the body being now called a *zygote*. The zygote resulting from fertilisation is at first a freely moving body, the *vermicule* or *ookinet*, which seeks out actively and penetrates the epithelial cells of the stomach wall. It now elongates, becomes very active, and works its way to the outer wall of the mosquito's stomach. Here it rapidly increases in size. The nucleus now undergoes numerous divisions. In the walls of the stomach it grows rapidly. In a week's time it is full grown. It has then a capsule around it, and, in its interior, a number of elastic spindle-shaped bodies called *sporozoites* or *blasts*.

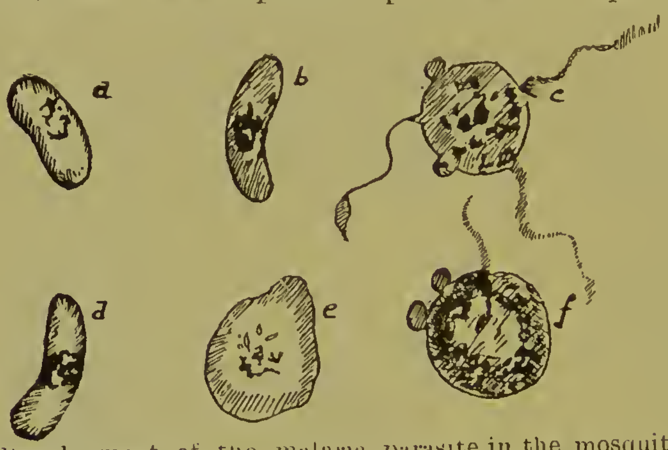


FIG. 71.—Development of the malaria parasite in the mosquito: a, b and c., the male gametocytes; d, e and f, the female gametocytes; f, fertilisation of the female gametocyte by a microgamete. (After ROSS and FIELDING-OULD.)

The capsule now ruptures and empties the sporozoites into the body cavity, whence they are transferred to the salivary glands, thence to the salivary ducts and proboscis, from which they are transferred to the blood of man. As soon as the rod-shaped sporozoites reach the blood from the mosquito, they in all probability begin invading the red cells and form ring-shaped bodies, which subsequently go through the developmental stages described in connection with amœbulæ. As each generation is succeeded by another their number vastly increases, until at length a sufficient number of spores are free, and a sufficient amount of toxin is created, to give rise to a paroxysm of fever.

The period for complete sexual development and reproduction of sporozoites in anophelines is six to ten days.

The great increase of reproductive power acquired by the development of zygotes, which occurs in the mosquito, must be considered as a secondary adaptation of a kind common in all forms of parasitical organisms, whereby the chances of disseminating the parasite amongst fresh hosts is greatly increased by the vast number of sporozoites or germs produced from each individual.

It is assumed that without sexual reproduction, the malarial organism would, after asexual multiplication for a number of generations, become exhausted and die out. As far as the individual person is concerned this is what actually takes place, when properly treated by quinine ; for then the young forms, which would eventually have given rise to sexual forms, are destroyed. Hence quinine properly given is a definite disinfectant of the blood in the bacteriological sense. There is a certain amount of experimental evidence to support the hypothesis that conjunction of male and female gametes involves a process of rejuvenescence whereby the cell is stimulated to renewed activity.

The gametocytes do not all appear in the blood during the first paroxysms of malignant tertian fever ; they usually do so in from a week to a fortnight after the first attack, and remain in the blood for several weeks. In simple tertian and quartan they appear with the early attacks of fever, continue in the blood for a a few days, and then disappear. When quinine is administered early in malarial fevers the gametocytes may not develop at all, especially is this the case with regard to quartan and simple tertian gametocytes.

There is still much in connection with the life-history of malarial parasites that we do not know, and one of the most difficult problems is the exact pathogenetic relation of relapses. We have been accustomed to believe that malarial parasites, like all other sporozoa, after several generations of asexual life, tend to exhaust themselves, but the recurrence of malarial fever for years in persons who have left the malarious locality in which they acquired malarial infection, and lived in non-malarious places, that is, without the possibility of re-infection, indicates that such asexual multiplication may continue almost indefinitely. In Lansdowne (5,600 feet) where there is no initial malaria, one has seen cases of such relapses going on for at least two years. There is undoubted evidence that such relapses may go on for a much longer period. There is probably much more in relapses than is accounted for in the simple explanation of parthenogenesis and a return of female gametes to " indifferent " forms.

In India there are as far as we at present know, only three forms of malarial parasites giving rise to the three forms of malarial fever met with.

(1) **Quartan parasite.**—This, known as the *Plasmodium malariæ*, gives rise to quartan ague, in which the attack comes on every 72

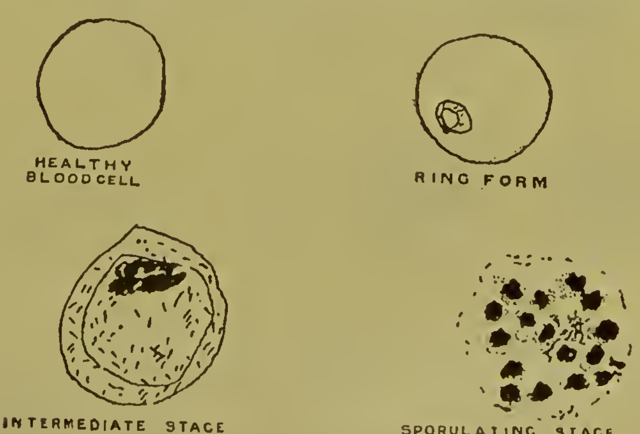


Fig. 72.—Quartan parasite.

hours. In this form the parasite invades the red corpuscles, sporulates, and in doing so forms from 6 to 12 spores, which give the invaded red cell a daisy-like appearance before it ruptures to set the spores free in the blood. In the human blood the life-cycle of this parasite lasts 72 hours. Two or more generations of the parasite may carry on their life-cycle in the blood simultaneously, giving rise to double or triple quartan ague.

(2) **Simple tertian parasite.**—*Simple tertian* or *benign tertian fever*, due to *Plasmodium vivax*, in which the attack comes on every 48 hours. In this the parasite invading the red blood cells also forms spores, which, when fully developed, are from 12 to 24 in number, and before the rupture of the cell, look like the petals of a rose inside the red cell. The life-cycle of the parasite is 48 hours. Two or more generations of the parasite may in simple tertian also carry on their life-cycles

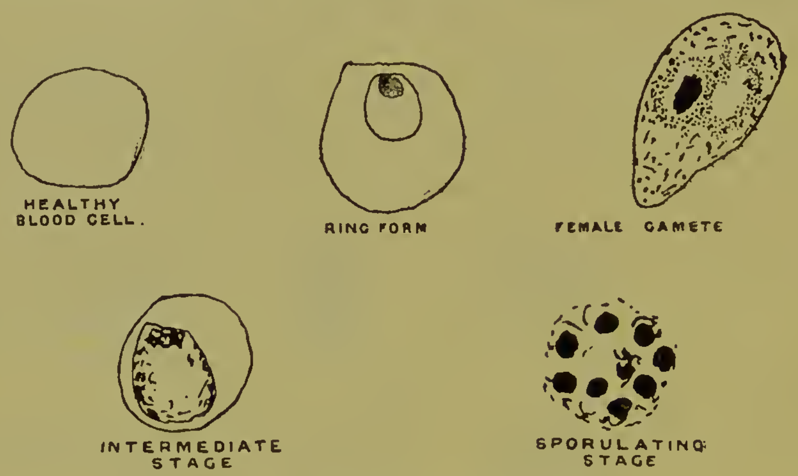


FIG. 73.—Benign tertian parasite.

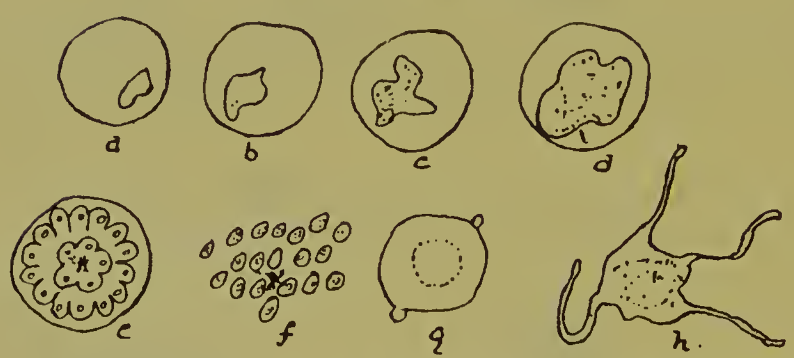


FIG. 74.—The benign tertian parasite: a, b, c, d, Amœbulæ; c, Sporocyte; f, Free spores; g, Female Gametocyte with so-called Polar bodies; h, Male Gametocyte.

simultaneously, giving rise to double or triple (rare) tertian ague. Stained by ROMANOWSKY stain in many cases the decolorised infected red corpuscles display a number of deep red granules—Shüffner's dots.

The vast majority of the cases of malaria in India consists of simple tertian, which is considered by most authorities to be the easiest form of malarial infection to eradicate from a locality and from infected persons. This does not correspond altogether with the experience of many experts in India. Notwithstanding statements to the contrary, the largest number of relapses occur in cases of simple tertian fever—this is, of course, accounted for by the fact that this is the predominating form of malarial fever. The generally accepted statement also that perniciousness (p. 462) is confined to malignant tertian is opposed to my personal experience, as one has seen such conditions as algid paroxysms, choleraic attacks, secondary pernicious anæmia, cerebral attacks, and even hyper-pyrexial phenomena, associated with simple tertian infection, whilst a fair proportion of cases of repeated simple tertian relapses or re-infections end in malarial cachexia. In discussing the subject with men of wide knowledge of Indian malaria it has been ascertained that one's experience in this respect is not exceptional.

In both quartan and simple tertian fever, the gametocytes (sexual forms of the parasite) are spherical in the human blood.

(3)—**Malignant tertian parasite.**—*Malignant tertian fever* due to *Laverania malariæ*, in which the typical attack comes on every 48 hours, but, as frequently there are two (or more) generations of the special parasite undergoing development simultaneously in the blood, the attacks often occur daily, or irregularly.

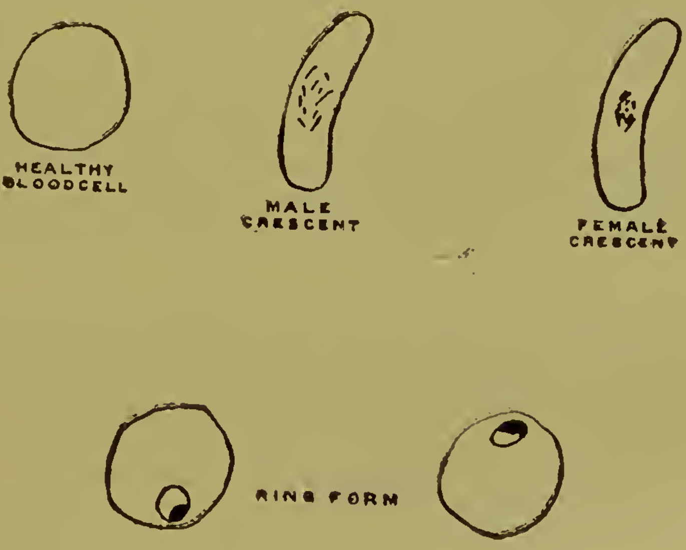


Fig. 75.—Malignant tertian parasite.

The gametocytes of the malignant tertian parasite are crescentic in shape in the blood.

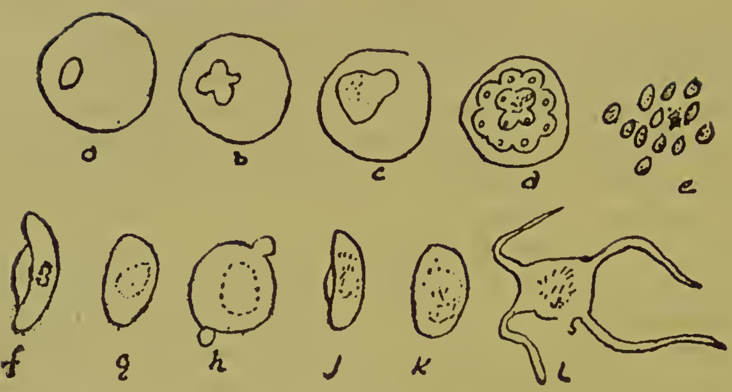


FIG. 76.—The sub-tertian parasite, a, b, c, Amœbulæ; d, Sporocyte; e, Free spores; f, g, h, Female gametocyte; j, k, l, Male gametocyte.

Varieties of malarial fever in India.—There are three varieties of malarial fever in India, viz., *Quartan*, *Simple* or *Benign Tertian*, and *Malignant* or *Sub-tertian*, each being caused by corresponding parasites which invade the red cells. Simple tertian and quartan malarial fever have usually been grouped under the common term *ague* or *intermittent fever*. This is inaccurate for several reasons, especially because they are due to distinct species of malarial parasites.

Incubation period.—This has been determined by direct inoculation of malarial blood, by observations after persons have been only one day in a malarious place, and by experimental production of malaria from infected mosquitoes. The incubation period varies from about 6 to 20 days.

The term *paroxysm* is applied to the period occupied by the three stages—cold, hot and sweating. The term *interval* is used to denote the period from the commencement of one paroxysm to the commencement of the next paroxysm. The term *intermission* is applied to the period intervening between the end of a paroxysm and the beginning of the next.

The malarial paroxysm.—When the parasites have increased in numbers sufficiently to produce enough malarial toxin to give rise to fever, the typical manifestation of malarial infection, the *malarial paroxysm*, begins. At this time all the red cells that are infected burst more or less simultaneously and set free many millions of spores and a corresponding amount of toxin and melanin.

Premonitory symptoms.—As the parasites are multiplying and approaching a sufficient number to give rise to an attack of fever, certain premonitory symptoms develop, such as general malaise, aching in the limbs and back, headache, chilly sensations and sometimes slight rises of temperature daily, before the fully developed attack. These symptoms may continue some days before the paroxysm sets in.

Symptoms.—The paroxysm in all forms of malarial fever consists of three stages—cold, hot and sweating—which may be more or less modified according to the species of the parasite, peculiarities of the individual, degree of susceptibility or sensitiveness to the effects of the malarial toxin, etc.

Cold stage.—There are peculiar chilly sensations, fleeting pains in various parts of the body which come and go, but increase in severity; then the chilliness increases rapidly, and if even a slight breeze reaches the patient he begins to shiver. He is now as a rule compelled to go to bed and a regular shivering fit usually occurs. The body shakes all over, the teeth chatter, the skin is pale or bluish, the papillæ of the skin are raised to produce what is called a "goose-skin" appearance. The patient feels intensely cold and piles over himself a heap of bed-clothes even in the hot weather. The nails and lips are blue. He lies in bed all huddled up. The pulse is small and increased in frequency, the breathing is hurried; headache may be very severe, and if he gets up he feels giddy. There is often vomiting. The temperature though low at the surface is high in the mouth and rectum. The urine is pale, in large quantity and of low specific gravity. This stage usually lasts from a few minutes to one hour, and at the end of it the temperature may be from 102 to 106° F. This stage is more marked in simple quartan and tertian ague; it is less marked, and sometimes even absent, in malignant tertian ague.

Hot stage.—This may set in gradually or suddenly. The temperature continues to rise and may attain its maximum about two hours after the commencement of the paroxysm. As the temperature goes up the shivering lessens and is then replaced by flushes of heat throughout the body. The skin is now hot, pungent and flushed; there is often vomiting and great thirst; the headache is more severe. The pulse is rapid and full. The temperature is from 102·5° to 105° F. or higher. This stage lasts a varying length of time, being usually 3 to 4 hours in quartan, 4 to 5 hours in benign tertian, and 16 to 20 hours in malignant tertian. The urine is scanty and high coloured. The spleen may be felt to be enlarged. This stage is practically always present.

Sweating stage.—The sweating usually begins about the head and is soon general. Beads of sweat begin to appear on the forehead, lips, chest and hands; often perspiration is profuse and drenching. The temperature falls and finally drops to a degree or more below normal, and the patient feels comparatively free from discomfort. Then the sweating ceases; the urine still continues scanty and high coloured.

The attacks usually come on every second day (benign tertian and malignant tertian) or third day (simple quartan) or daily (double benign tertian, double malignant tertian, and triple quartan).

The paroxysms are subject to various modifications, some of which occur as ordinary events, others are unusual and abnormal, *e.g.*, they may *anticipate*, when they come on earlier with each attack, or *postpone*, when they come on later.

The quartan paroxysm.—This usually lasts from 8 to 10 hours. There are seldom pronounced premonitory symptoms; the attack sets in sharply, the shivering fit, which is very seldom absent, is well marked and is associated with much discomfort, the fever is usually high going to 103° to 105° F. or more, and the sweating is profuse. All three stages are well defined.

The simple tertian paroxysm.—This usually lasts from 9 to 12 hours. Before the initial paroxysm there are often premonitory symptoms for several days. The shivering fit is as a rule less severe and the fever more marked and prolonged, the headache, vomiting and pains in the bones are more distressing, than in quartan.

The malignant tertian paroxysm.—This lasts from 24 to 40 hours. It is the most severe form of malarial fever, and represents a more profound degree of intoxication than the more innocent forms of malarial infection. The temperature chart is quite distinct from other forms of malarial fever. The temperature rises rapidly and keeps up for many hours, then there is a temporary fall, called the *pseudo-crisis*, after which the fever increases again, rising higher than it was previously, and finally dropping to well below the normal (crisis). The other symptoms are usually very severe, but the shivering fit is more often absent than in other malarial fevers. Sometimes, however, the shivering fit is severe and prolonged, or after the occurrence of several paroxysms the shivering fit, or even chilliness, may be absent. The temperature may run very high. The hot stage may last from 6 to 18 hours and may be followed by profuse sweating. There may be jaundice. If unchecked by quinine loss of strength may rapidly set in. Pernicious attacks are more commonly met with in this form of fever. In malignant tertian the fever is often more or less continuous with remissions, but not real intermissions. It is associated with coated tongue, there may be bilious vomiting, often pain in the "pit of the stomach" and tenderness from the vomiting, complete loss of appetite, and constipation or diarrhœa.

Malignant tertian fever is specially characterised by its disposition to irregularity, and to the production of a remittent fever, and by the frequency with which symptoms of a pernicious type develop (p. 462). The remittent or continued type of the fever in all probability is due to the grouping of the parasite in the blood, the intracorpuscular segmentation of which extends over comparatively long periods of time, creating paroxysms of long duration, which from their peculiar tendency to anticipation and postponement run into one another.

The greater part of the life-cycle of the malignant tertian parasite is passed in the internal organs and larger blood vessels, the younger ring forms and amœboid bodies only being met with in the surface blood. Proliferating parasites are, however, sometimes though rarely met with in the surface blood. The blood of the spleen contains an abundance of mature forms having clumps of pigment centrally arranged with the segmented parasite around, all contained in, and, being about half the size of, the red cell.

The gametocytes do not all appear in the blood during the first paroxysm of fever of malignant tertian fever; they usually do so in from a week to a fortnight after the first attack, and remain in the blood for a few weeks or longer. In simple tertian and quartan they appear with the early attacks of fever, continue in the blood for a few days, and then disappear. When quinine is administered early in malarial fever the gametocytes may not develop at all, especially is this the case with regard to quartan and simple tertian gametocytes.

In all forms of malarial fever the first paroxysms are liable to be prolonged beyond the average periods mentioned above. This is possibly explained by the fact that the parasites do not at first all sporu-

late together, but in successive groups, thus maintaining a longer discharge of toxin into the blood plasma. It is possible also that in the early attacks the person infected is more sensitive to the effects of the toxin. For these reasons a simple tertian paroxysm may continue until the next is due, giving the case the ordinary characters of malignant tertian fever. Conversely in those who have suffered from several paroxysms the attacks may be retarded or cut short by the parasites all sporulating together, and by the patient being less sensitive to the effects of the toxin. So mild are some attacks that people do not stop work. Malignant tertian, as regards each paroxysm, is as truly intermittent as ordinary simple tertian and quartan; when the fever is remittent or continuous it is simply the result of succeeding paroxysms running into one another without any intermission.

Single infections.—In single infections each paroxysm is due to the brood of the parasites that caused the preceding paroxysm. For example, a simple tertian or malignant tertian paroxysm occurring on Monday, the spores it sets free will infect the red cells and give rise to the next attack on Wednesday, and so on, leaving one day free from fever.

Double infections.—In this condition we have two groups of parasites of the same species which do not sporulate at the same time. In the case of simple and malignant tertian one generation would sporulate on Monday and Wednesday and the other on Tuesday and Thursday, and so on, on alternate days. Triple infections may also occur, there being three groups of the same species of parasite in the blood at the same time. In the quartan infection here the paroxysm would occur daily in the case of simple and malignant tertian somewhat complex forms of febrile paroxysms are met with.

It is obvious therefore that a daily fever may arise from double infection of simple or malignant tertian parasites, or a triple infection of quartan parasites. When this occurs it is observed that the paroxysm of one day is usually either more pronounced or less marked than that on the following day, showing that one group is playing a dominating rôle in the blood. A continuous or remittent temperature may arise from a prolongation of the paroxysm due to malignant tertian parasites, or to absence of simultaneous sporulation, or to unusual susceptibility of the patient to the effects of the toxin In such cases the paroxysms may run into one another, or the second paroxysm begins before the first has ceased.

Diagnosis.—Typical cases of malarial fever are not likely to be confounded with typhoid fever, but in cases of malignant tertian continuing for some time and unaffected by treatment a typhoid state (p. 439) is likely to appear. If seen at this stage and the blood is examined the diagnosis is clear, but if the blood is not examined the diagnosis may be very difficult. In cases of typhoid fever (p. 485)

we usually have diarrhœa, rose coloured spots on the abdomen, and the temperature chart differs from that of malarial fevers. The two diseases may co-exist.

Prognosis.—The prospects of recovery from malarial infection are almost invariably good when the patient tolerates quinine, can be provided with a proper quantity of suitable food, and especially if he can be removed from the endemic area. Pernicious attacks are always dangerous, especially if of the cerebral or choleraic form. Quartan and simple tertian fever, if not properly treated by quinine, may produce infections which last for years. Of the many complications of malarial fever the more serious are pneumonia, dysentery and diarrhœa, and this is particularly the case when they complicate chronic malarial infection. In practically all cases the infection can be eradicated, and further paroxysms prevented by the proper use of quinine.

Pernicious attacks.—When malarial infection is very intense or has continued for some time, it may suddenly lead to the manifestation of dangerous symptoms affecting one or more internal organs. These symptoms vary considerably, and are spoken of as *pernicious attacks*. They are as a rule rare, and occur in the most malarious places at the most malarious period of the year. The first paroxysm does not usually run into a pernicious attack, although it may do so exceptionally; it is as a rule only after the patient has suffered from several paroxysms that perniciousness mainfests itself, and this occurs most frequently in patients who have acquired no degree of immunity against malaria. There are usually vast numbers of parasites in the blood, though not necessarily the blood of the surface. Whilst pernicious attacks may occur in the more innocent forms of malarial infection they are more frequently connected with malignant tertian fever. Pernicious attacks occur mainly in people whose stamina is lowered from one or other cause, especially starvation, intemperance and excessive fatigue. They are always extremely dangerous, and come on suddenly, often unexpectedly. They usually manifest their characters after a series of preliminary paroxysms of apparently ordinary intermittent or remittent fever, and unless promptly and vigorously treated, are likely to be fatal.

The symptoms in pernicious attacks depend on the part of the system involved. The chief forms of pernicious attacks are due to implication of the brain and other internal organs, and the alimentary tract with malarial parasites. These need not be further considered here.

The chief changes that occur in malarial infection are—enlargement of the spleen, which may be enormous, filling the entire abdominal cavity; in recent cases the enlarged spleen is soft, in older cases the spleen is firm and called *ague-cake*; enlargement and some congestion of the liver, congestion of the bone marrow, vessels of the brain, and some congestion of the kidneys, and anæmia. The enlargement of

the spleen in cases of chronic malarial infection or malarial cachexia can usually be recognised as a swelling in the left side of the abdomen high up, and can always be felt in that region. Besides the actual red corpuscles destroyed by the parasites, a large number are destroyed by the toxins set free. This gives rise to the anæmia which is so obvious a symptom after several paroxysms have occurred.

Malarial Cachexia.

Clinical characters.—Repeated attacks of malarial infection improperly treated or not treated at all, are liable to culminate in the condition known as *malarial cachexia.* It occurs mostly in endemic malarial districts and especially follows malignant tertian, although it is by no means infrequent after neglected simple tertian, and even after quartan. It may occur after latent and masked malarial infections that have gone untreated and unrecognised.

The associated symptoms are—gradually increasing weakness, anæmia, palpitation, difficulty of breathing on exertion, loss of appetite, and diarrhœa; there is no real emaciation such as is seen in kala-azar. There are periodical outbursts of malarial fever and during the intervals the temperature is normal. The parasites are found in the blood during these pyrexial attacks and may completely disappear between them. There is always considerable enlargement of the spleen. This is one of the most frequent morbid conditions seen in the children of endemic malarial districts.

Of 3,884 children between 0 and 10 years of age recently examined in a large endemically malarious district, one found that 2,330 or about 60 per cent. had varying degrees of enlargement of the spleen; amongst the spleen cases there were 98 cases or 4·26 per cent. of malarial cachexia. The number of children with malarial parasites in their blood of the 3,884 was about 40 per cent.

Spontaneous cure of malaria.—It is within the experience of all medical men in India that in healthy persons a small infection of malarial parasites may be, and often is, completely thrown off. In all probability a similar infection, when the physiological resistance is reduced from any cause, would bring about definite symptoms of malarial infection. The human body possesses natural means of destroying the malarial parasite. The chief agency by which this is brought about is the large mononuclear leucocytes and to a much less extent the polymorphonuclears (see p. 150). The leucocytes effect the destruction of some of the parasites during the febrile paroxysm, and also ingest the disintegrated forms after the conclusion of the febrile attacks. When the nutrition of the body is perfect, this and other defensive natural processes are considerably helped, whereas when the vitality is lowered from any cause, spontaneous cure is hindered.

Relapses and Re-infections.—By a *relapse* we mean the occurrence of a malarial paroxysm or series of paroxysms, sometimes weeks or even months after an antecedent attack of malarial fever, without the intervention of a fresh infection—it is the re-awakening of the clinical phenomena by malarial parasites that have remained dormant in the body from a previous period. They are quite unconnected with re-infections. By *re-infection* we mean a new infection of the blood by

malarial parasites through anophelines, after the system has, by treatment or spontaneously, got rid of all parasites by which is was previously invaded.

Relapses must in India be looked on as one of the ordinary occurrences of malarial fever. It is now fully recognised that relapses may, by appropriate and prolonged administration of quinine, be entirely eliminated in any individual case and in groups of men under control and discipline. Without such treatment malarial fevers, especially in malarial districts, in the majority of cases are followed by relapses.

Treatment of Malaria by Quinine.

The alkaloid *quinina** was first extracted from the Peruvian bark by Caventou and Pellitier in 1820, and it was first used in India about 1845.

Quinine is the universally accepted curative and prophylactic drug against malarial fevers, and it is for these purposes the nearest approach to a specific that we possess. It has a decided and distinct influence on malaria by killing the parasites of the disease already in the blood.

In modern times a large number of substitutes for quinine have been introduced, some of which have been administered empirically, others because they should from their effect bring about the destruction of malarial parasites. In no single case can these substitutes compare in efficacy with quinine, they will not therefore be further referred to.

Method of administration.—Quinine is given by the mouth in solution, powder, tabloids or tablets and pills. The majority of medical men in India consider that the most satisfactory way of giving quinine to produce the maximum effect in the shortest time is in the solution by the mouth. Quinine in solution has the advantage of being quickly absorbed and producing its effects more rapidly than in any other way except by intravenous injection which is only resorted to in pernicious attacks. Until lately practically throughout the Indian Army and in jails this was the manner in which it was used both prophylactively and curatively.

Many medical officers in India now prefer the *hydrochloride of quinine* to the bisulphate. It contains 81 per cent. of the alkaloid, while the sulphate only contains 73·5 per cent., it is also said to be more stable and to reach the blood more rapidly. In whatever form quinine is used it is better to adhere to a uniform method of administration both curatively and prophylactively. Quinine is given in the form of powder by the mouth with the object of escaping the bitterness. Ordinarily the bisulphate is taken in rice wafer paper or suspended in milk,

* The word *quinine*, unless otherwise specified, refers to the *sulphate* salt of that alkaloid

or the powder is washed down with some tea or water. In this form it is inferior to the solution by about 25 per cent., hence a larger dose has to be given to produce a corresponding effect. It is suited to those who have a great repugnance to the bitterness of the solution. *Euquinine* is now being used to some extent instead of quinine; it is taken in the form of powder; if dissolved the bitterness of the quinine returns. As it is weaker in the alkaloid quinine, it has to be given in doses $1\frac{1}{2}$ times as large as the bisulphate.

In practically all cases the full effects of quinine (cinchonisation) are followed by ringing in the ears with some deafness, and in a few cases, slight giddiness. Actual dangerous symptoms of quinine poisoning are rarely met with. One has on only four occasions met with alarming symptoms from large doses. All four had taken from 35 to 52 grains in 24 hours. The general effects were—trembling, pallor, agitation, restlessness, anxiety, profuse sweating, palpitation, weak and frequent pulse; in one there was temporary collapse.

Dosage.—When administered *for the cure* of malarial infection children under 1 year may get from $\frac{3}{4}$ to $1\frac{1}{2}$ grains twice a day; those from 1 to 5 years $1\frac{1}{2}$ to 3 grains twice a day; 5 to 10 years 5 grains twice a day; 10 to 15 years 10 grains twice a day; after 15 years adult dose; adult dose 5 to 15 grains twice a day. In heavy infections threatening to overwhelm the system 50 per cent. more than the quantities named may be given.

Quinine in the cure of malarial fevers.—During malarial infection the object should be not only to check the paroxysms but also to eradicate all the parasites from the blood by the use of quinine; for this purpose the drug must be continued for at least three months and preferably for four months.

In all cases of malarial fever it is a sound rule to begin the drug as soon as the bowels have been acted upon by an aperient, if they are not already freely open. Quinine acts more promptly in malarial fevers when the bowels are well opened, and as there is a tendency to constipation, it is well to begin the quinine treatment with a purge such as a dose of calomel and compound jalap powder, Epsom salts, or a Seidlitz powder.

The best way of taking quinine is in mixture 5 grains to the ounce:—

Sulphate of quinine	...	... 1 drachm.
Dilute sulphuric acid	...	... 1 ,,
Water	...	... 12 ounces.

When 5 grains are to be taken one ounce is the dose, when 10, two ounces, 15, three ounces. This is much less liable to disagree than when the larger doses are taken in one ounce of water. It has fewer disagreeable after effects when taken just before a meal. The first mouthful of food removes the bitterness.

The following is the general plan one would advocate for a three months' course of curative quinine treatment.

The method begins after the last paroxysm or series of paroxysms.

First week.—

(*a*) In *double malignant tertian* (quotidian)—30 grains daily for three days, and then 20 grains daily for another 3 days, none on the seventh day, making 150 grains during the first week.

(*b*) For *ordinary malignant tertian*—30 grains on the day of the next expected attack, and continued on alternate days until 120 grains have been taken during the first week.

(*c*) For *double benign tertian*—30 grains daily for 3 days, and then 20 grains daily for 3 days, none on the seventh day, making 150 grains in the first week.

(*d*) For *ordinary benign tertian*—30 grains on the day of the expected attack, and continued on alternate days until 120 grains have been taken during the first week.

(*e*) For *ordinary quartan*—30 grains on the day of the next expected attack, and continued every third day until 120 grains have been taken.

For double and triple quartan the intervals between the doses would be shorter, and the amount of quinine to be taken in the first stage of the course larger.

From the end of the first week the course may be the same for all types of malarial infection.

Second week—15 grains daily.

Third and fourth weeks—10 grains daily with 20 grains every seventh day instead of 10.

Fifth to eight weeks (inclusive)—10 grains daily.

Ninth and tenth weeks—5 grains daily with 10 grains on two consecutive days each week instead of 5.

Eleventh and twelfth weeks—5 grains daily with 10 grains instead of 5 once a week.

Should a relapse or a re-infection occur while the patient is under this treatment (which is most unlikely) the whole course is to be commenced *de novo*.

These rules are general and not specific. The quantities mentioned are what one considers the average adult man should take. Some will require more, others less. There are many factors entering into the circumstances of cases of malaria that will necessitate some modification of this method. Amongst these are the freshness of the infection at one end and chronicity at the other, inordinate sensitiveness to the toxins metabolised by malarial parasites, unusual susceptibility to the effects of quinine, quitting the malarious for a non-malarious locality, etc. It is not possible to formulate any rules for quinine administration for three months that would cover the peculiarities met with in all patients.

The parasites of malaria, when they have once increased in sufficient numbers to produce malarial fever, are difficult to get rid of permanently. One personally believes malaria to be one of the most difficult of infective diseases to eradicate. Nothing short of a three months' course during the non-malarial season, and a *four* months' course (including one month's prophylactic use) during the malarial season (when it is assumed that re-infections are repeatedly occurring) is sufficient for this purpose.

There is an essential difference between the curative use of quinine in cases of malarial infection, and that of its use as a prophylactic. In the former case there are already hundreds of millions of malarial parasites in the blood; in the latter when successfully carried out, even when, as may be the case, infection is continuous and repeated, the number of parasites rarely reaches the proportion of one in half a milllion red cells. Literally, all use of quinine in malaria is curative, for it is employed to kill parasites that have entered the blood through anophelines. The term *prophylaxis*, as applied to quinine, signifies prevention of malarial paroxysms In chronic malarial infection quinine should be continued during the period parasites are present in the blood and given in smaller doses afterwards.

Prophylaxis by quinine is now adopted amongst all troops. It is also in vogue amongst the greater number of Europeans residing in endemically malarial places.

Wherever quinine is being used prophylactically to bodies of troops its use should be rigidly controlled and issued directly under supervision of some responsible officer. The prophylactic use of quinine is not as a rule popular, and all possible forms of evasion are practised by those who dislike it. Naturally the object in quinine prophylaxis is to achieve the desired result of preventing malarial fever with the minimum expenditure of quinine given in the most practical way.

Most effective method of using quinine prophylactically.—One's personal experience is that the best prophylactic dose of quinine during the malarial season where malaria is comparatively mild is 5 grains daily; where it is severe, 5 grains daily for 6 days and 10 grains on the 7th day weekly, and where it is very severe, 5 grains for 6 days

and 15 grains on the 7th day weekly. With these three degrees of malarial intensity it is probable that the results of 10 or 15 grains once a week, 10 grains twice a week, and 15 grains twice a week, in the last two cases on consecutive days, would be slightly inferior to those recommended above. The great advantage of the five-grain dose is that it never has any deleterious effect and never cinchonises.

The great objection to the daily use of quinine as a prophylactic to troops is that connected with its administration under responsible supervision. One has, however, seen it carried out in several regiments without the least trouble. Tablets are much more popular than solution of quinine.

Whichever method is adopted it should be adhered to consistently; that chosen will of course be the one compatible with all the local conditions to be dealt with, the amount of responsible supervision that can be given, and control over the drug being important factors. The plan to be adopted having been chosen, the length of time over which it is to be used should be fixed and a definite record of its effects kept up.

The rationale in the effects of the methods of administering quinine prophylactically differs. When quinine is given in small doses at frequent and regular intervals, the object aimed at is to keep always in the blood a certain amount of the drug, so that when parasites are injected by anophelines they are rendered *hors de combat.* In this method the minimum quantity of quinine that can effect this desirable object is used. The weak point is the probability that the drug will be forgotten or not taken for some reason one day and then the parasites may gain the upper hand; when they have once got a foothold in the blood small doses may not eradicate then. Quinine does not, of course, prevent malarial parasites gaining access through bites of anophelines. Quinine when present in the blood in sufficient quantity simply renders malarial parasites harmless when they are injected, by preventing the initial spore-forming cycles.

In the large dose method, that of giving large doses at intervals of some days, the object is to have the drug in the blood in such a degree of concentration that malarial parasites, should they meanwhile gain access and begin their spore-forming cycle, are quickly and easily killed, as they are, even if taken at the end of the intervals between the doses, in such few numbers and so easily assailed in their sporulating stages as to be readily killed. On the whole the object arrived at is attained in both methods in the same way. We know that quinine is fairly rapidly eliminated from the system, and that by the end of the interval in the large and infrequent dose method there is practically none in the blood. In the small dose method there is always a certain amount in the circulation ready. The small dose is the more ideal way, and simulates the form of acquired immunity. Those who advocate the five-grain dose daily hold that by this method the quinine accumulates in the blood in sufficient quantities to kill any parasites reaching it, and yet not sufficiently to produce cinchonisation. Further they consider that the curative effects of quinine when malarial fever does occur is not lessened by the system being accustomed to the smaller doses. It is to be remembered that the small dose methods do not affect the occurrence of relapses when malarial paroxysms have previously occurred.

Quinine not literally prophylactic but curative.—Quinine cannot be regarded literally as a *prophylactic* against malarial infection, as it does not, of course, affect the entrance of the parasites into the

blood, nor does it prevent the first stages of the development of parasites in the blood. The drug weakens or kills the parasite after it has infected the red cells, and at the moment the spores are set free from red cells.

We cannot lay in a reserve stock of quinine in the system ready to attack malarial parasites when they arrive. All experience indicates that this is a useless waste. Quinine administration during a pre-epidemic period is probably little or no use, and has been abandoned as a prophylactic measure. It is best to start its use as soon as the risk of malarial iufection occurs.

Principles of general prevention of malaira.—The principles underlying the geueral prevention of malaria are—

(1) That malarial fevers are due to a species of protozoon which invades the blood of man.

(2) That this protozoon reaches the blood of man through some species of mosquitoes of the sub-family *Anophelina*.

(3) That in these mosquitoes the malarial parasite carries out the sexual part of its life-history, undergoes developmental changes which are usually complete in from 6 to 10 days, at the end of which time they reach the salivary glands of the mosquito, whence they are discharged once more into the blood of man.

(4) These malaria-carrying mosquitoes breed chiefly in terrestrial waters in tropical and sub-tropical re ions.

(5) That quinine kills malarial parasites.

About the foregoing statements there is uow uot the smallest shadow of doubt. They are scientifically established *data*. In the preceding pages are to be found an overwhelming mass of evidence which bears them out.

In the present state of our knowledge it is reasonable to make three propositions :—

(1) Were all mosquitoes exterminated malaria would cease;

(2) Were all persons protected against the bites of mosquitoes, no malarial infection could arise;

(3) Were all existing cases of malarial infectiou cured then malarial disease would be extermiuated.

It is just possible that there is a gap in our knowledge, but for the practical anti-malarial sanitarian such a possible hiatus has to be ignored.

As corollaries to these three propositions we have the following:—

(1) If mosquitoes can be diminished or prevented from attacking man the chances of dissemination of malaria are reduced.

(2) If cases of malarial infection are lessened in number the chances of communicating the disease from man to man by anophelines are reduced.

Present preventive measures are sound.—One has no hesitation in stating that our present recognised methods of protection against malaria are scientifically sound, although in many places, difficult to apply. In the public prevention of malaria we should avoid councils of perfection, *e.g.*, large drainage schemes, insisting on the isolation of all cases of malarial fever, wire-gauze netting for doors and windows, universal use of quinine in the population, etc., in all places indiscriminately; it is our duty to endeavour to do as much as possible in each direction. We should employ as many of the known preventive measures as are practicable in the localities concerned, for we know that every individual success has its influence for good. The best anti-malarial results so far have been obtained in places where all preventive measures have been put into operation more or less simultaneously, and continued over a long period. This, however, has always been found to be somewhat costly. All public preventive measures against malaria necessitate the expenditure of money, sometimes large sums being required, and they always mean a great deal of work as well as some knowledge of general hygiene. Some anti-mosquito campaigns have erred in dealing first with large or extensive and difficult projects instead of the cheaper and easier ones. One of the most usual causes of failure of anti-malarial measures is that of endeavouring by one public health measure to eradicate malaria, and its abandonment after it has been found to fail.

The average malarial intensity of a locality depends on many factors, such as the number of children who harbour malarial parasites, the number of infected anophelines, extent to which individual prevention is practised, etc., so that the cause of failure may not be always easy to ascertain. To ged rid of malaria in any particular locality by artificial means may take several years; this is the usual experience of the limited number of instances in which it has been achieved.

No system of preventions covers all places.—It is impossible to give the details of the measures to be adopted in all cases—these have to be determined by local circumstances; in some places all measures may be adopted, in others only a few are possible. In intensely malarial areas, in many cases, do all we may and malaria is not mitigated. For example, there are certain regions such as the valleys

of our large rivers in India, Burma and Assam, where breeding grounds for anopheline larvæ are almost universal; others in proximity to extensively irrigated lands under rice cultivation; in such places anti-mosquito measures must be of limited use in the depopulation of these insects.

Prevention of Malaria in Cantonments.

Importance of anti-malarial measures in cantonments.—It is impossible to emphasise too strongly the importance of anti-malarial measures in cantonments in India during peace times. The vast majority of cases of malarial fever occurring on field service are those in which initial malarial infection was acquired in cantonments.

The malaria of cantonments is to a large extent bred in the human occupants and anopheline population of cantonments. One is aware of the fact that there are exceptional stations in which this statement is only partially true, but in the main the statement holds good.

There is a considerable amount of malaria amongst native children in cantonments. Of 3,884 children examined one found an average of 60 per cent. with enlarged spleens, and 40 per cent. with malarial parasites in the blood. Even in European troops' children the spleen was enlarged in 32 per cent.

European troops are exposed to malarial infection in various ways—through attacks of anophelines infected by both European and native children, punkah coolies, and followers generally; by visiting in the evening bazaars, coffee shops, soldiers' homes, Army Temperance Association rooms, and on "sentry go."

Repeated changes of troops from malarial to non-malarial places may have the effect of introducing endemic malaria into the latter, or of making slightly malarious localities highly malarious. There have been several instances of this in cantonments in late years.

Relapses can be prevented.—Relapses occur when previous infection is not eradicated by proper treatment. In order to prevent relapses a prolonged course of treatment is required. The course of quinine treatment one would recommend is that laid down on p. 466. All troops and followers known to be infected by malaria should be subjected to this course of quinine treatment, or some modification of it, for not less than three months. An occasional dose of quinine taken irregularly is not sufficient—it is a delusion and a snare to consider that a dose every now and then when one thinks of it will prevent a recurrence of malarial fever. Relapses in soldiers and all other bodies of men under discipline in this country can, and should, be controlled.

The method of treating malarial fever cases with quinine for a week or two only is one of the many reasons for the 'continuance of malarial infection amongst our troops. Under such treatment the administration of quinine is discontinued just at the time when the patient is most infectious to others through the gametocytes

in his blood. The real way to treat malarial fevers in station and regimental hospitals is to keep the patient in hospital and under quinine until gametocytes are no longer to be found in the finger blood. When this stage is reached the man can no longer, for the time being, communicate malaria to others through anophelines. In all probability gametocytes continue in certain internal organs—spleen, bone-marrow, brain capillaries, etc.—long after they cease to be found in the peripheral circulation. It is these gametes, and some other unknown phase in the life of the parasite that require to be eradicated, and until this is effected, the infected person is liable to relapses, that is, to recurring paroxysms without re-infection.

Admission into hospital and isolation of cases of malaria:—The detection, isolation and specific treatment of the infected soldiers are, as in other communicable diseases, of great importance in the prevention of malarial fevers. In most stations malarial patients are now isolated in special wards and supplied with mosquito curtains; in many instances the whole of the wards in hospitals are made mosquito-proof by wire-gauze doors and windows. All known cases of malarial fever should be admitted into hospital—they should not be "detained" or allowed "to attend." This is very necessary in Native regiments where the men on returning to the lines infect their comrades and frequently get re-infected themselves, there being always, in the malarial season, abundance of malaria-carrying anophelines present and infected native children. The advantage of remaining in hospital is emphasised when, as is now the case in many instances, the hospital is provided with mosquito-proof wire-gauze doors and windows. When malaria becomes epidemic, and the hospital accommodation insufficient, the overflow cases should be put into tents and not allowed to return to the barracks which only serves to perpetuate the epidemic.

All soldiers suffering from known malarial infection should be treated with quinine continuously for at least three months after the last paroxysm. When, as is the case during the malarial season, re-infection is liable to occur, the necessity for such treatment is emphasised. Were this done there would, I believe, be very few cases of relapses in the late winter, spring and summer months. *There should in troops be no residual malaria.*

All cases of malaria taking quinine curatively should get their quinine *at the hospital* daily for three months; this enables the medical officer to see the men regularly.

If the treatment of relapses begins after the malaria season is over, a three months' course is, as a rule, sufficient. The occasional failure of even this lengthy course is no justification for its condemnation. When in any case there is an unusual amount of residual enlargement of the spleen, it is advisable that quinine be given curatively for four months at least, no matter what the period of the year is in which it is commenced, and should the end of this course arrive during the malarious season, these cases should, like all other men, get quinine prophylactically.

In malarial stations in many cases European troops during the malarial season may with advantage be removed into camps well away from native towns and bazaars, on the principle of *segregation of the healthy*. The keeping of European troops in hill stations until the malarial season is over is a measure that is of considerable advantage to efficiency.

The sending of cases of malarial infection to non-endemic hill stations and to Europe excludes the possibility of re-infection and, as far as we can judge, places the malarial parasites under unfavourable conditions for multiplication. When, however, this change is very abrupt, chills are liable to occur and these by lowering the resistance of system predispose to relapses.

Prophylactic issue of quinine.—During the malarious season quinine should be issued prophylactically to all troops and followers in cantonments.

When to begin prophylactic issue of quinine.—When all cases of malaria in units are admitted, and such admissions reach from 2·5 to 3 per cent., I consider the prophylactic issue is justifiable. The longer it is delayed after this the higher will the percentage of fresh infections become during the malarial season. One would not lay this down as a hard-and-fast rule for adoption. There are circumstances when a prophylactic issue should be made irrespective of the percentage of admission, *e.g.*, on manœuvres at the end of autumn when in a district known to be malarious, or in barracks when there is a sudden rise in the malaria of the civil community around. Nor can the percentage named be adopted in all regiments at present, as in some the cases of malaria actually admitted are 3½ times less than those "detained." Assuming a uniform distribution of cases in barracks, any greater percentage than 2·5 or 3 means that one or more men in each barrack room are infected, and that through them, in the presence of anophelines, malaria will rapidly spread by infection acquired in the barrack. Under ordinary circumstances such spreading of malaria does not occur through cases in the barrack room of European troops, but through the infected anophelines from married quarters and followers' huts invading barrack rooms.

The effect of the percentage of cases of infection in influencing the incidence of malaria may be seen in every endemic malarial district. When the prophylactic issue is postponed until the percentage of cases to strength reaches 5, the effect on the incidence for some weeks will be comparatively insignificant. The men in barracks are then in all probability infecting one another through malaria-bearing anophelines. In such instances the maximum prophylactic doses of quinine should be commenced at once, *viz.*, 5 grains daily for 6 days and 15 grains on the 7th day every week, or 15 grains on two consecutive days weekly. The condition of malaria in the civil population is another useful guide as the time to begin quinine prophylactically. In troops, as a rule, the maximum incidence occurs later than it does in the civil population of the same stations, the number of residual cases of malaria being greater in the latter than in the inhabitants of cantonments.

All children in cantonments with enlargement of the spleen should get a three months' course of curative quinine treatment, receiving a dose daily.

When anti-mosquito and anti-larval measures are impracticable or hopelessly futile, our methods of prevention are limited to the use of quinine prophylactically, segregation, and mechanical defence against mosquitoes (mosquito curtains) of healthy and infected alike, and complete treatment by quinine of all malarial cases to eradicate the parasite.

Eradication of malaria from children living in cantonments.—In a recent report on malaria one wrote: "I would strongly recommend that all children up to 10 years of age including those of European troops living in cantonments, be given quinine curatively for a period of three months during the ensuing year. If on account of the expense all such children cannot be given it, I would recommend that every child with enlargement of the spleen be given it for that period. This course may be commenced at any period of the year. Say it is begun on the 1st January, by the end of the year its effects on the malarial incidence in troops would be ascertained. The object aimed at is to eradicate malarial parasites from these children This three months' treatment would only be necessary once, for although there would in succeeding years be once more a gradual rise from a low spleen rate to a higher, the rate of this rise depending on the assiduity with which cases of malaria occurring in children were treated, the effects would last for some years at least. When the spleen rate in any future year reached 25 per cent., the method, in possibly a more perfected form, could be adopted again.

One has drawn up a scheme indicating what is considered the best general method of carrying out this eradication of malaria in cantonment children. It is possible that local circumstances may call for modifications of it. In all cases the details as to the methods of distribution in units require thought, judgment and tact, so as not to arouse prejudice against the drug. It is advisable that medical officers endeavour to explain to parents the advantages of the use of quinine to the children, and the objects of the continuous administration for the period of three months.

The drug will have to be taken to the different followers' lines and regimental bazaars and a daily parade of all children held. This parade should invariably include all children, whether with or without enlargement of the spleen, for by this means any cases of malarial fever met with would be at once placed on the list of those to get a three months' course. The parents should not be relied on to administer the drug to children. In the case of European troops' children, the parade for the inspection and issue of quinine could be carried out at the more central of the married quarters and should be invariably supervised by a medical officer.

The method proposed is as follows :—

1 An indent for a three months' supply of quinine of 50 per cent. of the children of all units, including those of followers, should be submitted taking the average at three grains a day for each child. This is assuming that only half the children have enlarged spleen ; in some cases the proportion will be lower, in most it will be higher.

2. A spleen index should be taken of all children in cantonments attached to each unit, a nominal roll of those with enlargement of the spleen being made at the same time. This should be taken by the medical officer in charge of the unit. From this the actual amount of quinine required would be made known. Say there were 150 children, including those of followers and combatants ; this would mean that about half an ounce of quinine a day, and roughly three pounds for 3 months, would be required.

3. A regimental order should be published in units that *all* children are to parade daily at a particular time and place, and that all children with enlargement of the spleen or malarial fever are to be treated for three months, receiving a dose of quinine daily.

The nominal roll, which would give the ages, informs the medical officer as to the number of half grain and one grain powders, or the amount of mixture required for children up to two years. For those over two years pills or tablets can be administered. The dosage would be—

Years of age	Under 1	1	2	3 to 5	7	10
Dose in grains	½	1	1½	2	3	5

4. In the case of native units the administration should be carried out by the medical officer and the sub-assistant surgeon With European troops, by the medical officer attached to the unit and an assistant surgeon, or the sub-assistant surgeon, doing duty with the cantonment hospital. In large cantonments, a sub-assistant surgeon on special duty could carry this out under a medical officer.

5. At each distribution the nominal roll would be called and the name of each child on the roll, as it gets its dose, be ticked off.

6. I would also recommend that this quinine treatment of all children with enlarged spleen be supplemented by the use of an application of the red iodide of mercury ointment of the British Pharmacopœia, made with simple ointment from bazar ingredients. It is cheap, and such an application would appeal to the parents and give confidence in the whole course of treatment, the mothers could apply it to the children or the latter to one another. A brief monthly report of the progress of the work and its effects would be forwarded by medical officers of units to the senior medical officer, and at the end of the three months, a more detailed statement would be submitted showing the amount of quinine and ointment used, the effects on the incidence of malarial fevers and on enlargement of the spleens in the children.

It would probably be difficult to obtain a sufficient number of one grain tablets, hence for smaller children pills, powders, or mixture will be required. For infants quinine solution is the most convenient, in the proportion of one grain to two drachms of water.

I consider this curative treatment of all children living in cantonments by quinine for at least three months, that is, daily dosage according to age for this period, and subsequently during the malarious season the use of quinine prophylactically, to be urgently necessary The object aimed at is the eradication of malarial parasites from that portion of the cantonment population mainly harbouring them, and through whom, with the aid of malaria-carrying anophelines, malarial infection is to a large extent maintained in our troops.

One is confident that if rigidly carried out in its integrity under responsible supervision, its degree of success will be considerable, and that, if even partially carried out, it will effect a marked reduction of the malarial incidence in troops.

Mosquito nets and mosquito-proof doors and windows.—In the case of European soldiers in barracks located close to native quarters and the breeding grounds of anophelines, when these latter places on account of the expense or for other reasons cannot be abolished, it is probable that the best method of prevention is that of providing wire-gauze mosquito-proof doors and windows, or mosquito nets for beds, and the regular prophylactic use of quinine during the malarial season.

The objection made to mosquito nets is that during the hot summer nights they are warm inside and close out the wind. This objection may be overcome by allowing the men, after the monsoons have set in and the great summer heat subsided, to sleep in tents, located at least half a mile from any source of malarial infection. This is a compromise on the method of segregation of the healthy from those infected. In most parts of India as the hottest months are not the most malarious, and the nights are comparatively cool, this objection to mosquito nets does not hold good. In all probability if mosquito nets were issued to all soldiers free, they would be used and malarial fevers considerably reduced in the Army. When so issued their proper use and care should be made a matter of discipline. From personal experience one knows that soldiers willingly and intelligently use mosquito curtains provided. Many soldiers in different stations buy their own mosquito nets, in other stations this purchase is aided by regimental or institute funds. Hence it cannot be stated that heat prevents the use of mosquito nets. Nets are specially necessary for European troops when quartered in forts and other localities in the midst of native towns and cities, where anti-mosquito measures are impracticable. This is the case in such places as the forts in Delhi, Agra, Fatehgarh, Lahore, Ferozepore, etc. In such cases it is also very necessary to change the fort garrison as repeatedly as practicable—once a month at least.

The introduction of mosquito-proof wire-gauze doors and windows for barracks in malarious stations is considered by some experts to be one of the most economical ways of reducing the admission rate for malaria in European troops in this country.

Punkahs are used in all European barracks and help to keep off mosquitoes, but they are certainly not a reliable protection against mosquito bites. In many stations in the United Provinces and Punjab, such as Meerut, Delhi, Peshawar, Rawalpindi, etc., punkahs are stopped before the end of the anopheline season on account of the cold nights.

Rational hygienic living as an aid to prevention of malaria.—To maintain good health, however, in malarious stations, all other precautions as regards personal hygiene are to be adopted, temperance in eating and drinking, abundance of healthy exercise, good and wholesome food, protection from chills, etc.

No matter what form of mechanical protection is provided, one would emphasise the necessity of continuing such minor works as can be carried out by mosquito brigades, especially the abolishment of all small breeding places of mosquitoes, filling up hollows and borrow-pits, draining off small collections of water, grading ditches and keeping them clear of weeds, oiling pools that cannot be removed, etc. This work should be in the hands of the cantonment committee and superintended by the sanitary officer of the station under the orders of the senior medical officer. Anti-mosquito measures are in many stations regarded as impracticable owing to the difficulties of dealing with

rice fields, irrigation canals, and other large masses of water in and around cantonments. In some cases the effects of cantonment authorities are rendered futile because the breeding grounds of mosquitoes are near cantonments and under the jurisdiction of civil municipal commissioners who will not co-operate.

Main anti-mosquito measures for cantonments.—The chief anti-mosquito measures required in cantonments are included in—rough canalisation of rivers, streams, irrigation canals and water-courses generally; levelling, grading and embanking of rain-water channels, ditches and roadside drains; filling up of tanks, borrow-pits, excavations and depressions generally; covering of disused wells; covering, or periodical emptying, or kerosining water cisterns; filling up excavations for bullock runs; kerosining twice a week all small collections of water that cannot be abolished; prevention of excavations for building purposes within 1,000 yards of cantonments; removal of brick factories to 1,000 yards at least of cantonment limits; and disuse of grass farms within 500 yards of barracks when these are near the breeding grounds of anophelines. One would further refer to a few of these measures that appear to be of special importance.

Rough canalisation of streams.—Where rivers run along cantonments, it is possible by proper embankments and regulation of the bed during the seasons of low water to considerably lessen the facilities for the breeding of anophelines. One is constantly reading in reports that because a river or a large irrigation channel is on the confines of cantonments and towns, it is useless to make any effort to reduce anophelines. This policy of allowing things to continue in the old way is one that is responsible for much of the inactivity displayed in regard to anti-mosquito measures.

Irrigation channels.—Where irrigation channels run along cantonments with various branches through regimental lines, as at Peshawar, Mardan, and many other places in the Punjab, something can be done by (1) placing automatically acting droppers containing kerosine oil at the head channel; (2) grading and levelling the channel so as to maintain a flow of at least 2½ feet per second; (3) and clearing them of all grass and weeds periodically. Weeds and grass may be prevented by a similar automatically acting dropper containing a solution of sulphate of copper (strength 1 lb. to 10 gallons of water). Where the cantonment can afford it, these channels should be made *pukka*; where not, then the men operating as mosquito gangs can keep it level, and by rough canalisation and proper grading maintain a uniform flow.

Brick factories.—No brick factory should be allowed within 1,000 yards of cantonments. The making of barracks for native troops and followers with *pukka* bricks joined by cement would do away with the excavations now created by the use of mud walls and sun-dried bricks. The initial cost would be greater but the outlay is justified from many points of view.

Borrow-pits.—The creation of borrow-pits or excavating the surface soil for any purpose whatsoever should be strictly prohibited within 1,000 yards of cantonments. The construction of barracks should not be considered complete until every excavation created within 1,000 yards during such construction has been filled up and properly levelled.

Rice cultivation.—Rice cultivation should not be carried on within a mile of cantonments.

Thatch roofs foster mosquitoes.—Thatch should not be used for the use of Native troops or followers' barracks. Thatch roofs harbour mosquitoes during the malarious season, and also serve as places in which they may either hibernate or æstivate during the non-breeding seasons, that is, winter and summer. Tiles are preferable. Mosquitoes cannot stand the heat attained by these during the summer. During, and for a time after, the rainy season it is much easier to capture anophelines in a thatched house than in any other.

Mosquito gangs in cantonments.—The mosquito gangs of cantonments are chiefly employed in kerosining large and small collections of surface water, disused wells, garden cisterns, and fire buckets. Kerosining large bodies of water is a useless waste. The sphere of usefulness of mosquito gangs can be considerably extended. Important parts of their real duties are—filling up small and medium-sized borrow-pits, holes, excavations and depressions in the ground generally, including the shallower parts of large tanks; collecting old pots and pans, broken and discarded chatties, broken bottles, and anything in which water may collect; removing grass and weeds from roadside and other drains and ditches; levelling the beds of large and small *katcha* roadside drains and ditches, and collecting anopheline larvæ. This work should be carried out systematically, the labour fairly divided amongst the men, regularly supervised by some responsible cantonment authority, such as the cantonment magistrate, cantonment sanitary inspector, sanitary officer, senior medical officer and other member of the cantonment staff. These officials should be acquainted with all possible breeding grounds of anophelines in the station and allot tasks to the mosquito gangs.

Another use of mosquito gangs is that they keep officers and all ranks interested in the work of mosquito reduction in their compounds and barracks and in anti-malarial measures generally. The success achieved also indicates how readily and inexpensively anti-mosquito measures on a small scale can be carried out in private bungalows.

In a mosquito gang of three men, one should be provided with a pick, another with a shovel, the third carrying the larvicide used, as well as wide-mouthed bottles for anopheline larvæ, when collecting these latter. These bottles should be ready labelled, and one of the three men should be able to write in vernacular where the anopheline larvæ were found. The more useful and intelligent of the three should be the headman, who keeps the gang at work and does the same work as the others, himself getting, say, one rupee a month more pay. All larvæ collected should be examined, in large stations by the medical officer in charge of the station laboratory, in small stations by the sanitary officer on duty or by medical officers of units.

Mosquito Inspectors.—One would recommend that for a year or so each large cantonment employ a man for ascertaining the breeding places of mosquitoes, capturing winged anophelines and supervising the work of mosquito gangs. This man would be the cantonment mosquito inspector. These duties could be taught to any intelligent man within a fortnight. A staff of such inspectors could be readily created out of junior sub-assistant surgeons, and, although expensive, it would in large cantonments be an economical measure in the long run. In this

case the duties could be considerably extended and made more technical. They would ferret out every breeding place of anophelines, identify all larvæ caught, capture adult anophelines in native quarters of cantonments and in the neighbourhood of cantonments, carry out blood examinations, spleen indices, and thus localise the malaria in existence. The same men could as part of their duty issue quinine to all native children in cantonments and keep registers of these cases. To be of special use, however, the initial training of sub-assistant surgeons in these duties should be sound so as to make them conversant in a practical way with problems associated with the prevention of malaria. It would be easy to arrange to hold a class for this training during the anopheline season in some large central malarious station. Such training would embrace the identification of the different species of anophelines of this country, their larvæ and eggs, methods of capture of winged anophelines, breeding out of anophelines from ova, demonstrations regarding the breeding places of anophelines, diagnosis of malarial parasites in fresh and stained bloods, methods of staining, the diagnosis of malarial fevers clinically, the action of quinine, the method in which it is used curatively in malarial fevers and prophylactically. The materials for such instructions are to be found in all malarious stations during the malarious season.

With the progressive decrease of breeding places of anophelines in and around cantonments there will, I believe, be a corresponding reduction in the amount of quinine that will be necessary for curative and prophylactic purposes in garrisons, and the amount of labour required to keep down the number of breeding places will become yearly less.

Prevention measures against malaria in cantonments should be independent of the measures adopted by the civil community. In the case of a regiment, company, troop or battery living in quarters located near native bazaars in civil lines and close to numerous breeding places of anophelines in such lines, anti-malarial measures to be successful must be independently carried out. This is a question affecting the anti-malarial and anti-mosquito measures of almost every large cantonment in India.

Malaria in the Army in India is usually mild.—In military life in India, except in a few stations, we do not see the more virulent effects of malaria, nor the results of chronic and repeated malarial infection such as one meets in villages in endemic malarial districts, because amongst our troops severe malarial infection is at once brought under treatment, and relapses and re-infection are, to a certain extent at least, kept under control by periodical doses of quinine in cases of known infection, and quinine prophylaxis when general infection threatens. Our troops are better housed, fed, clothed and looked after than the general native community of the country

Malaria imported by returning furlough men.—In the questions of the general epidemiology and prevention, the amount of malaria met with amongst our European troops in India is comparatively infinitesimal, and the number of such troops that acquire malaria from one another through anophelines is probably small. The same cannot, however, be stated of our Native Army. While the latter occupy our barracks, even in stations that are endemically malarious, we should, by all the measures at our disposal, be able to prevent malarial infection becoming widespread. This does not hold good with those who leave their regiments to go on furlough yearly. Each native regiment is allowed to send 15 to 40 per cent. of men to their homes for several months every year. They either in going and coming from their homes have to pass through intensely malarial zones as occurs with the troops of all our Gurkha regiments), or their homes are situated in endemically malarial places, which is the rule. The same holds good with all recruiting parties going to and returning from these places, and with recruits coming from them. The return of these men (except in non-anopheline hill stations), serves to disseminate malaria amongst other men of the corps through anophelines, and where there are European troops in the station, probably to these also. The obvious remedy here is to allow men to go to their homes only during the non-malarial season and to carry on recruiting during this season also; or to provide them with sufficient quinine to be used prophylactically throughout the period they are on leave or on duty. When

quinine is thus provided full instruction should be given as to how it is to be taken, and if it is found that it is not used, this should be dealt with as a disciplinary measure. My personal experience of the use of quinine in this way is that it is very unsatisfactory and only influences the malaria to a small extent. It is better to examine all returning furlough men for malaria and treat all cases of infection found with quinine for three months.

Medical inspection of troops and followers before going on field service.—By regulation every regiment must be medically inspected as to its physical fitness before going on service. The medical history of regiments should be examined as regards malaria. All men with a strong malarious history should be rejected, not only on account of their being temporarily "unfit," but because in the presence of anophelines, they are a source of infection to others. All followers must also be examined. They are much more likely to be infected than the troops as many of them live in bazaars. Previous residence in the hills is a point in favour of sending a regiment on a campaign. One could quote numerous instances from the records of campaigns in the Indian Empire, where the advantages of this were demonstrated. Campaigns, marches, or journeys through malarious districts should, when practicable, be undertaken during the known non-malarious months. A large number of the permanently established camping grounds on the main roads between stations are located adjacent to native villages, and are therefore, for reasons already stated, sources of infection to troops occupying them during the anopheline season. Most of these camps were fixed upon antecedent to the establishment of the mosquito-malaria hypothesis. Camps thus located are convenient as regards water and supplies generally, but we should be aware of the risks when locating troops in them Quinine prophylaxis is often required under this circumstance. One can recall instances of the ordinary selected regular camping grounds for troops on the march from one station to another where these conditions prevailed and which accounted for most of the cases of malaria occurring among the soldiers.

Prophylactic issue of quinine on field service.—If the malarious tract covers more than one day's march, a prophylactic ration of 5 grains of quinine should be given every evening, beginning on the evening of the day of the first march So long as the force continues in the malarious region, this prophylactic ration of quinine must be continued. It may, in some very malarious places, be necessary to give 10 grains daily.

Tablets are more popular than mixture and, all things considered, are the most practicable method of using quinine on field service. It is specially necessary that the men should have a meal of coffee or tea and some solid food each morning before marching. When a malarious country has to be marched through, a full stock of quinine for prophylactic use should be supplied to regimental hospitals, field ambulances, and field medical depôts. In reputedly malarious regions the force should avoid, when possible, camping in the neighbourhood of villages and towns—the youthful population of such places and many of the adults are infected with malaria. Anophelines of the malaria-bearing species are necessarily present, and if our camp is within their range of flight, troops must get infected. In such places the local residents should be excluded from camps, and our men prohibited from entering the villages or towns.

Latent malarial infection always with the force.—In taking the field it may be said that, as in the case of typhoid fever, we have always a certain number of cases of malarial infection in the force, who, in the presence of malaria-bearing anophelines, are a source of danger to others. This arises partly from the way in which we treat cases of malarial fever in the Army in India. The ideal way of treatment in a regimental hospital would be the complete isolation of malarial fever cases from others by day and night in mosquito-proof wards, the administration of quinine, and its continuance until all the gametocytes have disappeared from the finger blood.

I would recommend that in every cantonment printed leaflets be distributed and placarded in English and the local vernaculars giving a brief and simple account of the essential causes of malaria, stating that it is due to malarial parasites in the blood, that these parasites are conveyed from man to man by certain kind of mosquitoes, that these mosquitoes breed in water, and that quinine kills the parasites in the blood. The leaflets should contain sketches of normal red blood cells (p. 148), red cells infected by malarial parasites (pp. 457, 458), adult anopheline and culicine mosquitoes (p. 451), anopheline and culicine larvæ in water (p. 450), and a few words as to how to distinguish the winged insects and their larvæ.

The following is a sample leaflet which one suggests for universal distribution and placarding in English and the local vernaculars in cantonments.

Causes and Prevention of Malaria.

Malarial fever is due to parasites in the blood. There are two kinds of cells in the blood, red and white. Malarial parasites attack the red cells.

These parasites are carried from man to man by certain kinds of mosquitoes; the two chief kinds of mosquitoes are called *Anophelines* and *Culicines*. Anophelines are the malaria-carriers. Anophelines when resting on a wall hold their bodies at an angle to it, the head, the proboscis (the biting mouth-parts of a mosquito), and the body are in a straight line, and the insect looks like a small thorn stuck slanting in the wall. Culicines rest with their bodies parallel with the wall and appear as if hunchbacked In anophelines the colour is light or dark brown, in culicines grey, brown, or black with white bands or markings. In anophelines the wings are spotted, in culicines the wings are plain.

Anophelines, like all mosquitoes, breed in water. In water they lay eggs, the eggs hatch, and larvæ are set free. The eggs of anophelines can only just be seen in water in which they float singly; the eggs of most culicines occur as little boat-shaped masses, those of others float singly.

The larvæ of anophelines are the young forms that live in water. They are easily known by their lying flat just under the surface of the water, and by their moving backwards in jerks; culicines hang in water head downwards from a long breathing tube, and move forward with a wriggling motion.

About a fortnight after the eggs of anophelines are laid full grown mosquitoes are formed and fly away. If barracks, houses or huts are near, they enter and feed on man's blood. If the blood contains malarial parasites these undergo changes in anophelines and in about ten days, if they bite a healthy person, that person gets malarial fever.

Anophelines may breed in any collection of water in barracks, houses, pools; outside barracks and houses, in cisterns, drains, tanks, wells, canals, streams, rivers and water channels of all kinds. Hence it is very important to prevent mosquitoes getting at the water in or near houses by keeping water vessels covered, and to prevent

water collecting near houses; any unnecessary articles that can hold water, such as old broken chatties, kerosine oil tins, broken bottles, etc., should be cleared away from barracks, houses and huts. All pools of stagnant water near barracks, houses and huts should be abolished by filling up the holes in which they occur. When pools cannot be filled up, a little kerosine oil (about an ounce or half a *chittack* for a square yard of surface) should be thrown on the surface of the water once or twice a week; this kills all mosquito larvæ. It is wise to try and kill all mosquitoes found in houses.

Quinine kills any malarial parasites that get into the blood. A small dose of quinine every day prevents malarial fever altogether; when malarial fever occurs large doses cure it, but to completely kill all the parasites in the blood it is necessary to take a dose daily for three months. Nearly all children have malarial parasites in their blood, and most children have also enlargement of the spleen due to these parasites. All children who get malarial fever, and all who have enlargement of the spleen should be given quinine every day for three months. This will completely cure them of malaria.

During the malarious season every one should take quinine regularly to prevent malarial fever.

Kala-Azar or Tropical Spleno-megaly.

Synonyms.—Dum Dum Fever—Black Fever—Kala Dukh—Tropical Cachexial Fever.

This disease occurs epidemically in Assam, and endemically in several parts of India, Ceylon and Burma; it is met with along the foot of the Garo Hills, in and near Calcutta, Madras, and along the Eastern Himalayan Terai. Kala-azar is now known to be more widespread in India than was formerly conceived, and each year we find cases represented in both the European and Native Army. In some stations (Dum Dum, Dehra Dun, etc.) it is said to be endemic.

It is a chronic, specific, infectious, parasitic disease, arising from infection of certain internal organs (spleen, liver, lymphatic glands, blood vessels and blood) with what are known as Leishman-Donovan bodies (which are small animal parasites), and is characterised by general enlargement of the spleen and liver, irregular intermittent fever, anæmia, a progressive and peculiar cachexia, associated with darkening of the complexion, sweating at night, diarrhœa or dysenteric symptoms, with ulceration of the bowels and sloughing of the mouth or other parts. This disease is very like malarial fever at the beginning without malarial parasites in the blood, and it is like malarial cachexia in the end. The association of the Leishman-Donovan body with a clinical condition very similar to that of malarial cachexia has necessitated a closer investigation into the two groups of similar cases, and the outcome of all recent observations is the conclusion that a certain number of cases formerly called malarial cachexia were in reality kala-azar. The parasite which causes the disease can readily be seen under the microscope in stained preparations of the blood from the spleen or liver, and sometimes from the blood taken from the finger.

All evidence at our disposal at present appears to indicate that kala-azar is caused by *Leishmania donovani,* and that it is in all probability spread by some insect.

Captain Patton, I.M.S., has shown that the parasite of kala-azar may in many cases be recovered from centrifugalised blood, by which process the leucocytes containing the parasite may readily be isolated, stained and examined as ordinary smears. Kala-azar appears to attach itself to houses and may be considered a domestic disease, which favours the view that it is communicated to man through some insect. So far no treatment has been of any avail. These parasites are entirely intra-cellular and are found chiefly in the larger mononuclear leucocytes (p. 150) on smears and in the endothetical cells of the vessels of the liver and spleen *post-mortem.* The parasite as seen in the spleen, bone-marrow, and in advanced cases in the finger blood, is a round or oval body about $\frac{1}{8}$ to $\frac{1}{10}$ the size of a red corpuscle; it has two small bodies in it which stain deeply with the usual stain for malarial parasites, and

surrounding these, a body-protoplasm containing vacuoles. The bone-marrow cells contain many parasites, the yellow marrow in the shafts of long bones is converted into red marrow, and is much decreased in consistency. These parasites have a large and a small nucleus not unlike the micronucleus and macronucleus of a trypanosome; and they have been cultivated in vitro in citrated blood by Lieut.-Col. LEONARD ROGERS, I.M.S., and develop into flagellated organisms which have most of the characters of herpetomonads: their development into the herpetomonad form has been followed in the stomach of the bed-bug (*Cimex rotundatus*) by Captain PATTON, I.M.S. The Leishman-Donovan body has likewise been successfully inoculated into dogs in this country and in Algiers. The evidence is rapidly growing that this parasite plays an important part in the fevers of this country. It is almost identical with the parasite that occurs in Oriental Sore or "Delhi boil." In all probability there are several varieties of this parasite.

The disease travels slowly along the lines of human communication, and can always be associated in new localities with the arrival of infected persons. It occurs in whole families and in the poorer and dirtier classes. It is not affected by season. The dwellings occupied by cases of the disease are infected and it can spread from one dwelling to those adjacent.

The period of incubation is said to be from three weeks to several months. It is a very fatal disease, and causes great mortality (96 per cent of attacks) in the epidemic areas. Whilst it attacks natives chiefly, it is by no means uncommon amongst Europeans. The disease attacks all ages and classes and both sexes. There is no racial immunity. At one time it prevailed in Dum Dum amongst European troops and was called "Dum Dum fever" which was then thought to be malarial in origin. It is met with occasionally in all parts of India.

Prevention.—As recent observations seem to indicate that this disease is disseminated by bed bugs, the special preventive measure would aim at their extermination. The use of bed-steads of iron or wood that can be taken to pieces regularly, and thoroughly freed from bed-bugs and their ova, would facilitate their eradication. These cases should be isolated and permanently invalided as unfit for further service as early as possible once the diagnosis has been confirmed.

RELAPSING FEVER.

Synonyms.—Famine Fever, Spirillar Fever.—This is an acute specific infectious fever of a relapsing type, setting in suddenly, lasting a week, with then a sudden fall of temperature, a period of remission of 5 or 6 days, followed by an attack similar to the first, but usually milder; the disease is due to a blood parasite (*Spirochæte carteri*). The disease occurs in practically all parts of India and may be met at any season. It is endemic in both the Bombay and Madras Presidencies, occurs all over the Punjab and in Baluchistan and in the Himalayan Terai. It is aggravated by overcrowding and insanitation, and it is specially connected with starvation, hence called *famine fever*. The period of incubation is from 3 to 5 or 7 days. The spirillum or spirochæte is

FIG. 77.—Spirochæte of relapsing fever.

extremely fine and exceedingly active, the parasite coiling and uncoiling itself constantly between the red blood cells. This parasite has not been cultivated outside the body. Monkeys may be affected by the disease; it can certainly be given to them by inoculation of the blood of persons infected with it. It is found in the blood only during the fever periods, and is in greater abundance in first than in the later recurrences, decreasing with each recurrence. The parasite is easily seen under the microscope in both fresh and stained blood preparations. There is a large increase in the white blood cells especially in the polymorphonuclear cells (p. 140) during the disease. It is infectious. This parasite is in all probability in India communicated to man through the ordinary bed-bug (*Cimex rotundatus*) which itself has been specifically infected from a previous case of relapsing fever. Infected bugs are capable of transmitting the disease to monkeys. The ordinary body louse (*Pediculus corporis*) has also been accused of carrying this spirochæte, and it has been suggested that mosquitoes may act as carriers. The parasite is now believed by most authorities to be a protozoal organism, although some consider it to be a bacterium of the genus *Spirillum*. There are several species of this spirochæte—at least four—connected with different forms of fever in man, but so far only the one named above has been found in India. It occurs both sporadically and epidemically, in jails and amongst large bodies of men closely aggregated during epidemic periods, and isolated cases occur everywhere in India and are often overlooked when blood examinations in fever are not carried out. The ordinary stain for malarial parasites (Leishman's) brings them out, but weak carbol-fuchsin solution is better

The predisposing causes are starvation, bad food, destitution, dirt, overcrowding, bad ventilation, defective hygienic surroundings generally and aggregation of the sick. The mortality is above 5 per cent. of those attacked, but in some epidemics, as *during famine periods* it may be as much as 50 per cent.

Symptoms.—The onset is sudden with chills and frequently with vomiting, pains in the back and limbs, fever; the temperature rises to 103° or 104° F., reaches its acme, and remains there for from 5 to 7 days. There is usually aching of the back and limbs, depression and much prostration; delirium is often present and there may be sweats. Vomiting is a common symptom, especially in the early stage. These symptoms end suddenly (crisis) with profuse sweating and occasionally diarrhœa, the urgent symptoms abate and the patient feels almost well. The fall of temperature is rapid, in most cases to below normal. After about a week's freedom from fever, there is, in the majority of cases, a sudden recurrence of the first symptoms, but they are usually less marked

A second, third and even a fourth similar relapse, each less and less severe with a more intermittent fever and longer periods of freedom from fever, may take place. The bowels are usually constipated; occasionally there is a critical diarrhœa. The tongue is often dry and brownish with red tip and edges. The spleen is enlarged in more than half the cases, often the liver also. Sometimes there is cough with congestion of the lungs. Sometimes "typhoid" symptoms (p. 440) arise with jaundice and enlargement of the liver; occasionally the urine is greatly diminished. If death occurs, it is due to some intercurrent disease such as pneumonia, or rapid loss of vitality.

The following table will assist in distinguishing between ordinary cases of relapsing, typhus, and typhoid fever:—

	Relapsing fever.	Typhus fever.	Typhoid.
Duration ...	Is a 7 day fever. Relapse occurs about the 12th to 14th day from the invasion, and the 5th to 7th from the critical sweat of initial attack.	Is a 14 day fever ...	Is a 21 to 28 day fever.

	Relapsing fever.	Typhus fever.	Typhoid.
Age affected	All ages	Adult life ...	Youth and adolescence.
Rash ...	There is no characteristic eruption. Dark patches (patechiæ) often present which differ from those of typhus by not appearing in centre of the original spots.	Mulberry-coloured rash. Patechiæ.	Rose-coloured rash, occurring in successive crops on the abdomen, chest and back.
Occurs ...	Epidemically or sporadically	Epidemically ...	Endemically mainly.
Cause ...	Starvation and overcrowding predispose. The *Spirochæte carteri* (also called *S. recurrentis*) is the *exciting cause.*	Starvation, overcrowding and insanitation predispose. The real cause is not known.	It is caused by the *bacillus typhosus.*
Chief symptoms.	Muscular pains. Tenderness and enlargement of the liver. Sudden cessation of the fever. The spirochæte is found in the blood during the fever stage.	Active delirium frequent. Peculiar dusky coloration of the skin	Diarrhœa often a prominent symptom. Rose rash. Low muttering delirium. Widal's reaction with the serum. The bacillus may be cultivated from the blood.
Mortality ...	About 5 per cent ...	About 10 to 12 per cent.	Varies from 5 to 20 per cent.

Prevention.—In view of the probable part played by bed-bugs in transmitting the disease from man to man, the indication is to maintain complete cleanliness of the barracks and all their appurtenances, including bedding, clothes, bedsteads and furniture. The most frequent places in which bugs are found are the joints of bedsteads and furniture. These should be made so that they can be disjointed and cleaned periodically. Bugs are readily destroyed by applications of boiling water, kerosine oil, carbolic acid, and acetic acid. Acetic acid poured between the joints of bedsteads and furniture kills the bugs there. A pleasant way of killing bugs in a room is fumigation with carbolic acid and camphor, four ounces of each to be mixed and ignited for every 1,000 cubic feet of air space; it does not prevent the eggs from hatching out. Sulphur fumigation is also successful (p. 427). Mattresses and pillows might be covered with some washable material such as Willesden canvas.

Typhoid Fever—Enteric Fever.

This is an infectious disease characterised by a long stage of fever, with great prostration, the prevalence of rose-coloured spots appearing in successive crops chiefly on the abdomen and lower part of the chest, with a tendency to diarrhœa; it is associated with lesions involving certain glands of the bowels, and enlargement of the spleen. It is caused by the *bacillus typhosus* which is usually introduced into the body with drinking water, milk or other food, and is found in the intestines, spleen, fæcal discharges,

urine, and in the blood. A convincing proof that this bacillus causes the disease is the selective *agglutination** or Widal's reaction

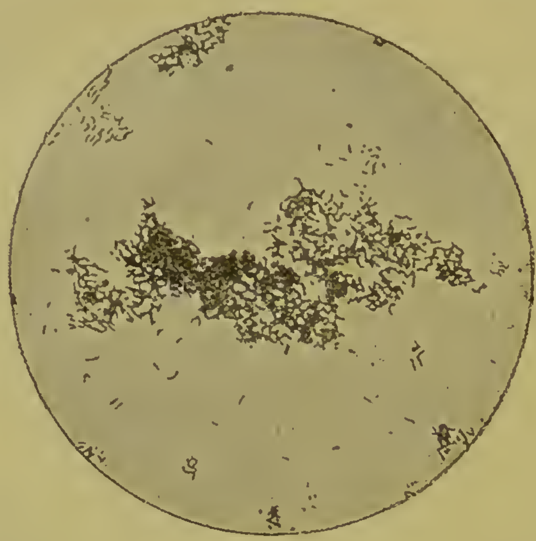


FIG. 78.—Agglutination of typhoid bacilli, in the blood serum of a typhoid fever patient, showing a large clump of bacilli. Before the addition of the serum the typhoid bacilli were isolated as seen in Fig. 79. Magnified 350 times. (After HEWLETT).

of culture preparations of the bacillus by the serum of patients. The bacillus is one of the microbes which, under cultivation at any rate, produces little if any extra-cellular toxin, while in the course of recovery from the disease, or of artificial immunisation, the serum of the person acquires a specific bacteria-destroying property.

This is probably the most fatal disease of Europeans in this country. It is specially a disease of the young, the most susceptible age being from 15 to 25 years. It is particularly liable to attack young soldiers and young officers shortly after coming out, unless they are protected by anti-typhoid inoculation. Many of the earlier cases in a campaign are in all probability brought to the front by men leaving their stations in the incubation stage of disease.

Enteric fever accounts for about one-fourth of the deaths of British soldiers which occur in India every year. The average number for the five years 1905-09 in India shows 958·2 admissions and 186·4 deaths. Most of the men attacked are young and have less than two years' service. About one of every five attacked dies. Typhoid fever is as a rule more prevalent but less fatal amongst European officers than the rank and file.

It is a curious fact that there is an increasing number of *typhoid fever* cases in the Native Army each year, and this is associated with

* *Agglutination* here signifies a coagulative phenomenon which is associated with the death of bacteria, and is considered to be due to some deleterious effect on the covering or outer part of bacteria which makes them sticky. The material which brings about this adhesion of the bacilli in masses is called *agglutinin*, and is formed in the blood as a defensive agent against the bacilli.

a progressive decrease in the class of malarial fevers that used to be called *remittent fever.* It is very probable, however, that typhoid fever cases existed previously and that the apparent increase is due to more exact methods of diagnosis now adopted. The following shows the actual admissions in the Native Army for the years named—1902, 50; 1903, 80; 1904, 70; 1905, 130; 1906, 127; 1907, 182; 1908, 350; 1909, 284. The disease practically never occurs in an epidemic form in the Native Army.

The following table regarding European troops in India shows that typhoid fever has with few interruptions steadily declined since 1890, so that it is now only one-half as prevalent as it was then.

Enteric fever in European troops in India from 1890 to 1909:—

Year.	Admissions.	Deaths.	Ratio per 1,000 of strength admissions.	Case mortality per 100.
1890 ...	1,254	332	18·6	26·50
1891 ...	1,343	380	20·3	28·29
1892 ...	1,506	374	22·1	24·83
1893 ...	1,402	370	20·1	26·39
1894 ...	1,486	408	20·9	27·49
1895 ...	1,544	383	22·6	24·81
1896 ...	1,795	445	25·5	24·79
1897 ...	2,050	556	31·8	27·12
1898 ...	2,375	657	36·3	27·66
1899 ...	1,392	348	20·6	25·00
1900 ...	970	289	16·0	29·79
1901 ...	776	202	12·8	26·03
1902 ...	1,012	260	16·7	25·69
1903 ...	1,363	292	19·6	21·38
1904 ...	1,384	265	19·7	19·15
1905 ...	1,146	213	16·1	18·59
1906 ...	1,095	224	15·[illegible]	20·46
1907 ...	910	192	13·1	21·10
1908 ...	1,001	190	14·5	19·14
1909 ...	639	113	8·9	18·18

One is inclined to consider that the death-rate as recorded for typhoid fever in past years is a surer index of the incidence of disease than the actual number of cases diagnosed as such, as there is no doubt that some of the cases so recorded have been cases of one or other of the several lasting fevers met with in this country. When the method of diagnosis by cultivation of the bacillus from the blood is universally adopted, this source of error will be completely eliminated, and the real prevalence of the disease measured. Typhoid fever is one of the great scourges of European armies, particularly during campaigns, in standing camps, and whenever sanitation is at all neglected. In India (1905—09), 13·64 per 1,000 of our European troops suffer per annum, in the French Army 4·1, in the Russian 3·8, United States 3·6, German 0·9, and our Army at home 0·6 per 1,000. During

the 31 months of the South African War no less than 42,741 men were admitted for typhoid fever with 7,998 deaths, that is, considerably more than were killed by the enemy, *viz.*, 6,872; in the war with Russia, the Japanese in 18 months had 4,073 deaths from this disease.

The typical form of the typhoid bacillus is in length about one-third, and in breadth about one-fourteenth the diameter of red blood cells; it has slightly rounded ends. It is very motile, this activity being due to the 8 to 12 flagella with which it is surrounded. The *bacillus coli communis* has usually only 3 or 4 flagella.

FIG. 79.—Bacillus of typhoid fever. (After HEWLETT).

FIG. 80.—Bacillus of typhoid fever showing flagella. Magnified about 2,000 times.

A temperature of 140° F. kills the microbe in 15 minutes. Freezing does not kill it; it may survive in ice for weeks. In surface soil it may resist direct sunlight for so long as 122 hours (FIRTH and HORROCKS). It grows in all ordinary meda—agar, gelatine, bouillon and blood-serum. It stains by practically all the usual aniline dyes, but not by Gram's method. Its special properties are interesting because it is very much like certain other bacilli. Among these latter is *bacillus coli communis*, a normal inhabitant of the bowel, which sometimes becomes disease-producing. The typhoid bacillus differs from it in growing less vigorously in cultivating media, in having a greater number of flagella, the agglutinative reaction with the blood serum of typhoid fever patients in dilution is specific; and there are other differences in its cultural relations which we need not consider here.

Although some have attempted to show that the *bacillus coli communis* may under favourable circumstances become the typhoid bacillus, at present, as far as scientific evidence indicates, we can scarcely doubt the *specific individuality* of the typhoid bacillus. That paratyphoid organisms (*vide* p. 504) apparently distinct from, yet closely resembling the specific bacillus, can cause a disease closely resembling typh id fever, is now beyond all doubt.

The bacillus is discharged in the fæces and urine, and, when it attacks the lungs, in the expectoration, and possibly in the expired air. It is also contained in the rose-coloured spots and in the sweat. Everything that comes into con tact with the discharges of the patient

contains the bacilli, and if care is not taken with regard to the clothes, bedding, utensils, nurses' hands, patient's hands, etc., they may all get infected with the germs of the disease. Every place where the undisinfected discharges are thrown becomes a focus for the spread of the disease. Typhoid stools are specially infective during the early stage of the disease and during the early period of relapses. The urine in a large percentage of cases is specially infective at the end of the third week, and from then up to the 30th day. Late in the disease typhoid bacilli found in the fæces are probably mostly from mixed urine. The urine in 25 per cent. of cases contains enteric bacilli. As many as 172 millions of typhoid bacilli have been counted in a single drop of urine from a typhoid patient. Flies are considered to be important carriers of typhoid germs. They are dirty feeders, visit latrines and other accumulations of dirt. In latrines they lay their eggs in human fæces, if these are accessible, and return to houses, alight on food, dishes, etc., carrying the germs of disease on their wings, mouth, feet and legs. If all houses were thoroughly clean, especially the stables, yards and latrines, flies could not flourish. As above stated the bacillus reaches the body through the bowel in the food, or liquid consumed. Rarely it gains access through the lungs. If it gets into the small intestines of a healthy susceptible person, it begins to multiply causing certain ulcerations in the mucous membrane, gets into the blood-vessels and can be found in the blood. Finding the bacillus in cultivations from the abstracted blood of the patient is the most immediate way we can diagnose the disease.

In practically every large cantonment in India it is now possible to make a diagnosis of typhoid fever within the first few days of the disease beginning by blood cultures; the technique of this method of diagnosis has been simplified and all difficulties in carrying it out eliminated. Recent results have shown that in practically every case of typhoid fever bacilli can be cultivated from the blood at this early period. Indeed one is disposed to recommend its adoption in European troops in every case of fever where the diagnosis is uncertain and the man has not previously suffered from the disease. It is more certain than Widal's reaction in which some of the factors connected with the reaction depends on conditions altogether unconnected with the patient.

After being swallowed the bacillus passes through the stomach, enters the bowel, creates toxins in its multiplication and these toxins get into the blood, travel through the body, and give rise to the symptoms of the disease. The bacilli in the blood do the same. Hence we consider typhoid fever to be essentially a blood poisoning due to the toxins formed by the typhoid bacilli.

In most regiments there is the probability that some persons are always suffering from manifest or undeveloped enteric fever or are "carriers" of the disease. In such cases the evacuations passed in the public latrines, and containing the infective material of the disease may be a source of the disease.

During the last few years much attention has been given to the question of the contamination of food by the chronic typhoid "carrier."

The chief points noticeable about the distribution of the disease in barracks now is that scattered cases occur promiscuously in different companies and troops, and that there is a marked seasonal prevalence There are, approximately, amongst our European troops, 858 cases yearly, of whom about 186 die, and 100 of the survivors are invalided leaving 700, in whom there are about 21 carriers. Of these 21 not more than 1 or 2 in the year are employed in connection with food in the whole European Army in India—hence the direct infection of food by these is an unlikely source of the disease. These chronic carriers must be looked upon as sources of indirect infection, but few in number compared with the unrecognised cases and of all the recognised cases before admission into hospital.* A large number of typhoid fever cases are not admitted for several days after the disease has begun, during which time they are acting as disseminators of the disease. The germs of the disease are not only discharged in the stools during the earliest stages, but also in the stage of incubation, and the disease is specially infective during the earlier stage (CONRADI).

There is much evidence to support the view that these men are at least one of the most frequent sources of typhoid infection. This points to the urgent necessity of insisting on all cases of even trifling fever reporting sick at once, and of the necessity of isolating these cases until the presence of typhoid fever has been disproved. Early diagnosis by cultivation of the bacilli from the blood of these cases is of paramount importance in the matter of prevention.

In April 1908 a convalescent depôt for men who had recovered was established at Naini Tal and during the year it received 310 cases. In each case the urine and fæces were examined for seven consecutive days, and none were sent back to their stations until at least four months had elapsed from the date the fever had left. Of 190 men whose excreta were examined in 3·1 per cent. the fæces (5 cases) and urine (1 case) contained bacilli at the end of six months. All were sent to England and continued to discharge typhoid bacilli for many months. The stations from which these 310 convalescents were sent showed an average reduction of fresh cases by 9·1 per cent., stations from which the typhoid convalescents were not sent showed an increase of 26·6 per cent A similar depôt for convalescent typhoid cases has been established at Wellington in the Nilgherries. In 1910, 239 typhoid convalescents were sent to the Naini Tal Depôt.

There is still a great deal of work to be done in connection with the morphological and clinical relations of the various species of bacilli closely related to the original *bacilli typhosus*, and the different paratyphoid bacilli; and much investigation has still to be carried out in connection with the epidemiology and endemiology of typhoid fever before we can assume that our preventive measures have reached the limits of possibility. Such investigations are being carried on throughout the civilised world, and military medical officers are the chief workers in this field.

Ways in which enteric fever is spread.—Enteric fever is usually spread by one of three ways—contact with previous cases, by water, and by food (especially milk).

Water-borne epidemics.—Water-borne epidemics of enteric fever are usually from some water-works or wells which have been contaminated by the special bacillus of enteric. This form of "mass infection" occasionally occurs through milk, and is due to the milk having been diluted with infected water, or to the milk utensils having been washed with contaminated water, less frequently by the hands of the sick, or of attendants carrying infection to milk.

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* Lieut.-Colonel A. R. ALDRIDGE, R.A.M.C., *Journal of the Royal Army Medical Corps*, September 1909, p. 225.

Investigation of sources of infection.—When enteric fever has undoubtedly appeared, we have to find out the source of infection. If we can exclude importation (it is seldom we are in a position to do so on field service), we direct attention to water and food, regarding which, evidence acquired in an epidemiological inquiry, readily incriminates or acquits. If water and food are eliminated in such an inquiry, infection by contact remains, and this part of the investigation may be difficult on field service, as it means a bacteriological examination of all suspicious cases of sickness in and out of hospital; and of what we know as "chronic carriers". "It is not possible by present methods to detect all sources of infection, and for the defence of those of a susceptible age, recourse must be had to anti-typhoid inoculation."

It takes 18 to 24 hours to grow colonies of enteric bacilli in nutrient media, and even then suspicious colonies have to be subjected to a series of other tests before identification is complete and absolute. This shows the impracticability of bacteriological examination of water as a rule in an enemy's country, or in the presence of the enemy. It is, of course, quite easily carried out on the lines of communication and during cessations of hostilities, and in standing camps.

Life of enteric bacillus in water.—In natural unpolluted water the *bacillus typhosus* may live for three to five days. The general opinion is gaining ground that the bacillus of typhoid fever in the natural condition in water is a short-lived microbe. It is seldom that this bacillus is bred from water examined, and this is so whether the water be centrifugalised, or the contents of the water be sedimented, or precipitated by chemical agents, or by agents which prevent the growth of other microbes, or even by specific serum. The general characters of most of the reported outbreaks of enteric fever in late years are opposed to its being due to specifically contaminated water or milk. For example, it occurs in one set of lines, or two sets adjacent, in one camp, or two camps contiguous, even when the water-supply is identically the same throughout the station or cantonment. Nevertheless we should never forget that many of the epidemics of former years in India, and some of those of recent years in the United Kingdom, were undoubtedly caused by consumption of specifically infected water which has been pronounced by expert bacteriologists and chemists to be pure. Neglect of our water-supplies for troops would once more be associated with similar outbursts of the disease.

Specifically polluted water not the only means of infection.—Military sanitarians of wide experience in India, and a large number of both civilian and military hygienists in Europe at the present day, do not consider water as the only mode of disseminating enteric fever. They admit that specifically contaminated water may give rise to explosive epidemics of the disease, but these at the present day are the exception, and are comparatively short-lived.

Infection acquired in bazaars is said to account for a certain number of cases, and in some instances epidemics have been thus started, hence the necessity on field service of forbidding anything being eaten or drunk that has not been duly passed as fit for use. Hence also the necessity of placing all infected localities (both in peace and war) out of bounds. On the whole, however, bazaar infection is not a prominent factor in the dissemination of enteric fever in our Army in India.

Origin from contaminated aerated waters.—Aerated waters procured in bazaars have been considered to be a source of enteric fever outbreaks on several occasions in recent years in our European troops in India.

Imported enteric fever.—A large number of the cases in different stations are undoubtedly imported—importation is probably one of the most important factors in the dissemination of the disease in our Indian cantonments, and it is likely to be of overwhelming significance on field service, as we must necessarily always have a number of men of a very susceptible age with the force, in many of whom the disease is probably incubating; or men who, having recovered, still harbour its germs. It is difficult to conceive how we could successfully practise quarantine so as to eliminate incubating cases which are extremely difficult (in some cases impossible) to diagnose; from these carriers of infection fresh incubations would be constantly occurring. Daily, constant watchfulness to detect the earliest indications of the disease —fever, diarrhœa, general malaise (without reasonable cause), headache, etc., is imperative, and the elimination of these cases from the force, as well as the exclusion of all cases recently recovered from enteric, are obvious preventive measures against the spread of the disease.

How the typhoid bacillus escapes from the body.—The bacillus enteric fever may make its escape from the body through fæces (including bile), urine, and expectoration. The bacillus of enteric fever is found in the urine in from 25 to 30 per cent. of cases, although it is rarely found in this excretion before the second week of the disease.

Typhoid fever is essentially a blood disease or septicæmia.—It is popularly supposed that typhoid fever is a disease of the bowels. We now know definitely that it is not so, and that it is a true blood poisoning, a septicæmia (or bacillæmia). Certain glands of the bowels (known as Peyer's patches and solitary glands), which usually ulcerate in typhoid, are merely channels through which general infection arises. The bowel lesions are secondary to the general blood poisoning. It is probable that the throat, especially the tonsils, frequently serve as the initial focus whence the bacillus disseminates. It is well known that the fæces from start to finish of a case of enteric fever may never contain the bacillus, showing that there is possibly in some cases a local immunity of tissue in the bowels to the attacks of the microbe, which is one explanation for the escape of "acute bacilli carriers."

Endemic typhoid fever.—That typhoid fever exists in the endemic form (that is, it is more or less firmly implanted in particular localities) has for some years been a recognised fact in the history of the disease in this and other countries. This means that the germ of the disease has found its way to such places, and in them found conditions favourable to its continued growth and multiplication—has, as it were, taken root. In recent years sanitary and medical officers generally have considered that these favourable conditions for the germ are to be

found in the system of latrines so universally in use. It is not always easy to define in what particular direction these latrines become foci for its spread, but that dust from these latrines laden with typhoid bacilli and infected flies are important factors, is generally admitted.

In standing camps it becomes a soil disease.—Much of our recent experience in this country, and that gained in South Africa, seems to indicate that enteric fever is, when at all widespread in an area, what might be termed a soil disease, and that under this condition, pulverised and dried typhoid bacilli are wafted into the air, water, and food. The definite diagnosis of enteric fever in many cases during its early stage, and under the conditions of field service, is next to impossible. Yet such cases through their dejecta multiply the foci whence infection spreads.

Behaviour of typhoid bacillus in the soil.—In 1894, EBERTH demonstrated that the bacillus typhosus lived for months in soil polluted by sewage, and in ordinary soil for a short time only. We now know that in dry earth the typhoid bacillus rapidly loses its virulence (in 24 hours); in moist earth it remains unaffected for 24 hours; in nutrient earth its virulence is increased in 24 hours, and continues to increase for a time, then declines, and finally it dies. It would appear that the vitality of the bacillus of typhoid may withstand drying for some months. In the Cuban War specifically contaminated dust was considered to be a disseminator of enteric, and "flies undoubtedly served as carriers of infection. There was strong presumptive evidence to show that infection was spread to a considerable extent from the latrines by the hosts of flies which swarmed in many of the camps" just as "flies in India contribute their quota of cases of typhoid infection."

The conditions of camp life, especially those of standing camps on field service, are highly favourable to the spread and persistence of typhoid fever, once it has made its appearance.

Indications from the life of the typhoid bacillus in the soil.—The indication here is obvious. Once a man has typhoid fever in a battalion in camp, he must be sent to hospital, the tent he occupied must be vacated, disinfected and struck, the ground in and around the tent being subsequently treated with some disinfectant, and not occupied again. The "contacts" should be isolated for 14 days, kept under medical supervision, provided with separate latrines and urinals, all their excreta sterilised by incineration or boiling, and these contacts dealt with as if they were actual cases of typhoid fever. The bedding and kit of the patient, and all the contents of the tent he occupied should also be completely disinfected. The regimental latrines at this time require special supervision, and it is advisable to render the trenches harmless by the daily use of some liquid disinfectant, such as a solution of crude carbolic acid or saponified cresol. "Among the possible endemic centres of infection none are so common and dangerous as insufficiently supervised dry earth latrines infected by early or ambulant cases."*

*Lieut.-Col. GLENN ALLEN, R.A.M.C., *Journal of the Royal Army Medical Corps*, February 1907, p. 136.

Infection by contact.—Infection by contact may be (*a*) *immediate* from the sick person, especially when the disease is not diagnosed; or (*b*) *mediate* from articles contaminated by them. Infection may occur from early and ambulant cases; from mild or early cases in hospital prior to their diagnosis as typhoid, and from some of those who escape diagnosis altogether; by the excreta of convalescents after they are discharged from hospital; from men who are acting as bacilli carriers and, by infection, from badly placed and defectively worked latrine trenches.

Lieut.-Colonel SIR DAVID SEMPLE, R.A.M.C., states that those who harbour infection may be divided into four classes: Persons suffering from enteric fever diagnosed and treated as such; persons suffering from enteric fever but not diagnosed or treated as such, including attacks in which the disease was not suspected and possibly many cases diagnosed and treated as ordinary diarrhœa or simple continued fever; convalescent enteric fever patients who have become bacilli carriers; and healthy persons who have never so far as we know passed through an attack of the disease, such as attendants on enteric fever cases, or persons who have been subjected to the same opportunities of infection as those who contracted the disease—probably temporary harbourers of infection, but not infected in the ordinary sense of the term. The latter three classes are real propagators of the disease in India. The first is the least dangerous because known and defensive operations against them are taken.

Period of incubation.—This usually varies from 10 to 14 days but it may be from 5 to 35 days. During the period of incubation the patient may feel that there is something wrong, he tires readily, and is disinclined to do his ordinary work.

Symptoms.—It begins in various ways sometimes with a feeling of coldness or actual shivering, at other times with diarhœa, or pain in the abdomen. Then there is fever which compels the patient to take to his bed. For the first few days the fever rises two degrees in the evening and falls one degree in the morning, giving what is called a step-ladder thermometric chart, until the temperature reaches 103 or 104° F. There is usually headache, and there may be slight delirium. The tongue is coated with a white fur, the bowels are often loose, but by no means always so, as *there may be constipation* throughout the disease. The stools when the bowels are loose are of a peculiar pea-soupy character. At the end of the first week there are usually some rose-coloured slightly raised spots on the abdomen, and it may be also on the chest and back.

In the *second week* the fever continues and the patient suffers from delirium and mental confusion, he is more or less apathetic, the diarrhœa increases, the abdomen is tender and distended.

During the *third week*, in cases going on to a favourable termination, the temperature usually begins to fall and does so in the same way that it rose, that is, dropping one degree every day until it reaches the normal. But the temperature may continue high, the diarrhœa become worse, the abdomen more distended, the tongue get dry and brown, delirium worse, there may be pulmonary trouble, and the heart threaten to fail, or there may be perforation of the bowel owing to an ulcer giving way.

Usually during the *fourth week* the patient begins to feel better, the temperature falls to normal or even below, the tongue gets clean, the looseness of the bowels ceases, and the patient begins to be brighter and to feel hungry. At other times the patient goes from bad to worse with increasing weakness, with a heavier expression, dry tongue, stupor, muttering delirium, and involuntary motions. Many of these seemingly very serious cases get well.

During convalescence the greatest care must be taken to prevent a relapse which is liable to occur in all cases. This is best done by the strictest attention to diet which should consist of nothing but liquid food, chiefly milk for 10 days at least, after the temperature becomes normal. The patient often craves for food.

The *eruption* consists of small slightly elevated rose-coloured spots which disappear on pressure, and come out in successive crops. The *tongue* is first coated white with some redness at the tip and edges, but it soon becomes dry, brown and tremulous, and like the teeth, becomes covered with bacteria, saliva, epithelial cells, etc., forming what are called *sordes.* Slight congestion of the *lungs* with cough is usually present.

Walking or ambulatory typhoid fever.—The symptoms in this variety are so mild that the patient is able to walk about while suffering from the disease. In "abortive typhoid fever," there is an abrupt onset of symptoms which subside quietly, convalescence occurring in a few days.

Notwithstanding the frequency with which typhoid fever is met with, there are few diseases in which mistakes in the diagnosis are more common. The great difficulty in the diagnosis arises from the frequency with which some of its most characteristic symptoms are absent (*e.g.*, rash or diarrhœa) and from the indefinite nature of the illness in many cases. Apart from Widal's serum reaction, and the direct cultivation of the bacillus of typhoid fever from the blood, there is no single symptom by which the diagnosis can be made. A combination of many of the symptoms named, however, make the diagnosis highly probable. Amongst the special indications of the disease in combination are Widal's reaction, what is known as the diazo reaction, and a decreased number of white cells in the blood. This last is found to be present in 90 per cent. of cases of uncomplicated typhoid. Widal's reaction occurring in an individual who has not previously had typhoid or protected by anti-typhoid vaccination is nearly certain evidence of the disease, provided the test is properly applied. The possibility of the person having previously had the disease (often undiagnosed) is always to be kept in mind, for there is no doubt that this is the explanation of some of the positive reactions which occur in illnesses other than typhoid fever.

There are various diseases from which typhoid fever has to be distinguished but of these we need here only consider one and contrast it with typhoid fever—*viz.*, malignant tertian (malarial) fever.

Malignant Tertian Fever.	*Typhoid Fever.*
Onset generally intermittent ...	Onset gradual and progressive.
Irregular remissions. The temperature may arrive at 104° F. within 24 hours.	Regular though very slight morning remissions with evening exacerbations of temperature. The temperature does not reach 104° F. before the 3rd or 4th day.
Headache rare in beginning, of a neuralgic character, pulsating, variable in its position and intensity: there may be a slight jaundiced hue in eyes from onset.	Headache from beginning permanent, severe, frontal; eyes white.
The apathetic expression of the face, the dryness of the tongue and sordes on the teeth are not very marked.	These symptoms are usually well marked and progressive.
Breath foul ...	Breath has a peculiar mouse-like odour.
The delirium may come on in the early days—it is recurrent, but changes with the exacerbations of temperature and other symptoms, and may give way to grave symptoms related to other organs.	Delirium appears only when the disease is well marked and is often persistent and variable only in degree. Pulmonary congestion is gradual and persistent; the difficulty in breathing is pronounced and later in appearing, depending more on the abdominal conditions, distensions, etc.

Malignant Tertian Fever.	*Typhoid Fever.*
If there is pulmonary congestion, the cough and other symptoms come on suddenly, the areas affected change from one to the other lobe or lung, and may disappear and reappear again with varying intensity; difficulty of breathing is very pronounced, circulatory disturbances are marked, even syncope or collapse may occur.	There is congestion of the lungs, especially of the bases and back and during the later stages, in nearly all cases.
There are usually restlessness and anxiety.	There are usually relaxation, prostrations and stupor.
Peculiar greyish colour of skin, sometimes slight jaundice.	No jaundice.
Blisters on lips ...	Blisters on lips rare.
Anæmia more or less marked early in the course.	Anæmia absent except in later stages.
No characteristic eruption ...	Characteristic rose-coloured rash.
At times there may be distension of abdomen which is but slightly pronounced and is paroxysmal. Diarrhœa is slight or absent and has not the characteristics of that of typhoid fever.	Distension of abdomen, gurgling and diarrhœa appear slowly and may become well marked.
No distinct course, urine high coloured; may show a trace of bile.	Has a fairly characteristic course; urine high coloured.
Patient's serum does not cause agglutination of typhoid bacilli; malarial parasites and pigmented leucocytes are present in the blood.	Patient's serum agglutinates typhoid bacilli and malarial parasites and pigment are absent from the blood.
Fever disappears under quinine ...	Unaffected by quinine.
Is an endemic disease occurring particularly in rural districts; in some years it is epidemic.	Usually endemic but may be epidemic; prevails commonly in large communities.

Prevention.—Preventive measures employed under a clear understanding of the probable ways of conveyance of the disease, as a rule, ensure the safety of others against infection; nevertheless, in conditions of close association with the infected, the measures adopted are sometimes ineffectual, and when the recognised preventive measures are carried out in a faulty way, the direct transmission of the disease from subject to subject is by no means uncommon. Preventive measures are likely to fail in some outbreaks where there is close aggregation of many cases. It is highly probable that those in attendance on cases are infected through their own contaminated hands, either immediately or through food, or through the air around the patient becoming infected by disregard of the orthodox rules for disinfection.

Typhoid fever spreads through specific pollution of water, soil or food (especially milk) by the bacillus of the disease. It can only be maintained by the discharges from typhoid fever patients and typhoid

fever "carriers." One epidemic arises from contamination of water, another from contamination of the soil, a third from infected milk or from eating salads grown in land where fresh human manure was used; in another again from eating oysters grown in water contaminated by sewage. Probably a certain percentage of the cases of enteric fever are from specifically contaminated water or milk, and if these are both boiled for a few minutes all the germs are killed and that proportion of cases prevented. Salads should never be eaten unless washed with boiled water that has cooled. Uncooked celery, lettuce, beetroot and salads generally may carry the germs. Servants cannot be relied on to prepare salads in such a way as to render them quite safe. Where *fresh* fæcal matter is utilised to fertilise vegetable gardens there is always risk in using the vegetables although the products resulting from fæcal decomposition have no such effects (see pp. 196, 288).

The utmost cleanliness should be insisted on with regard to latrines in barracks and officers' premises, disinfectants being used freely. All carts, pails, and utensils taken to the night-soil depôts should be thoroughly cleaned and disinfected before their return.

The process of freezing does not kill the typhoid fever germ, therefore ice is not safe if the water from which the ice was made is infected.

There are four great public health measures, *viz.*, a pure water-supply, a food-supply free from specific contamination, especially a pure milk-supply, proper disposal of excreta, and the isolation of all persons acting as carriers of the disease.

It is now generally recognised that water-supplies in cantonments can rarely be accused of being concerned in disseminating typhoid fever. In the reports published by the Sanitary Commissioner with the Government of India for the year 1908, there was no single outbreak said to be due to water in the cantonments of India. Because we now recognise that infected dust and flies, and infected food are sources of typhoid fever (and probably also dysentery and infective diarrhœa), we cannot for an instant relax our vigilance on water-supplies—neglect of drinking water will in endemic areas be rapidly followed by explosive epidemics of the disease.

The establishment of Government and regimental dairies under strict medical supervision in a large number of cantonments has *pro tanto* eliminated another factor, the tampering with milk in dirty utensils by the *gowallah*, and it is earnestly hoped that ere long in every cantonment this possible source of enteric infection will b entirely eradicated.

The adoption to self-closing fly-proof doors and fly-proof windows to all barrack and station hospital kitchens, which in the barracks of European troops (but not in those of Native troops) is now universal, should render the access of flies to food impossible. There are also many kitchens of officers' messes in which this precaution has not yet been taken; no officers' mess kitchen should be without this protection from flies.

In a large number of cantonment latrines, an emulsion of cresol and water (1 to 320) has taken the place of dry earth; this is placed in the privy pans, and acts as a disinfectant as regards the typhoid bacillus, and prevents flies laying their eggs in the excreta. In trenches badly managed there are swarms of flies, and the night-soil carts from such trenches becoming covered with them carry flies back to the barrack latrines. In several cantonments the latrine seats are provided with self closing lids and with wire-gauze doors at the back of the seats to prevent the access of flies. The breeding of flies in dry refuse and stable litter has now in many stations been greatly reduced by the establishment of night-soil incinerators.

We are still obliged to guard against all the known possible sources of infection. Concentration of efforts of prevention in one or two main channels only is certain to be associated with failure.

"All sound methods of prevention must take into account the sources from which the infection is derived, *viz.*, enteric fever patients and bacilli carriers. Methods of prevention which fail to take these sources into consideration can end only in failure and disappointment. It is necessary to find out and isolate all those who harbour infection, and with this object in view particular attention should be paid to accurate methods of diagnosis, to chronic carriers, and to those who live under conditions where infection is to be expected. Before convalescent enteric patients are discharged from hospital or the sick-room, steps should be taken to ascertain whether they are free from infection, and any who are found to be infective should be detained until a definite conclusion has been arrived at as to whether they have become bacilli carriers. Bacilli carriers should have their condition explained to them, and they should be warned of the importance of cleanly habits. Disinfection of their excreta should be insisted on. On no account should they be employed in the preparation or handling of food, milk, or

FIG. 81.—Typhoid bacilli in urine of convalescent, after a relapse and two days after the temperature had permanently become normal. (After HORTON-SMITH.)

drink supplies. In a word they should be debarred from any kind of work which gives them opportunities for infecting other people. At present we know of no safe and reliable method by which a bacilli carrier can be made free from infection. None of the intestinal or urinary disinfectants that have been used are reliable for this purpose."

Amongst the indirect measures for preventing the possibility, or minimising the risk of latrine infection, and to eradicate endemic enteric fever in large cantonments, the following may be mentioned :— Quarantining all drafts and individuals on arrival, isolation of all "contacts," segregation of all suspicious cases of pyrexia and diarrhœa, thorough disinfection of latrines and urinals of the unit concerned, and segregation of the enteric fever convalescents for whom special latrines and urinals should be provided, all their excreta being sterilised before removal to the trenches (Lieutenant-Colonel GLENN ALLEN, R.A.M.C.). In some stations where incineration of excreta is not practised, the trenches are made deeper than before, and placed more remotely from barracks which diminishes the probability of flies breeding, and lessens the chances of their coming to the barracks.

Investigations of Major E. D. D. Grieg, I.M.S., in Alsace and Lorraine.— Major E. D. D. GREIG, I.M.S., in his report on the various measures employed in the campaign against typhoid fever in Germany states that the following facts are of importance in this connection :—

1. Typhoid fever is spread to a large extent by the bacilli being directly carried from the sick to the healthy; *e.g.*, infection of food, the use of contaminated eating and drinking utensils, etc. In this form of so-called *contact infection* the epidemic has a gradual onset and prolonged course. Should the bacteria gain access to a water-supply used by a number of persons, then a large number of cases occur simultaneously—the so-called "explosive epidemic" occurs. The medical workers in Germany have found this latter mode of infection of comparatively rare occurrence as compared with the former.

2. That living bacilli may continue in the fæces and urine for long periods after the fever has ceased, and that persons who give no history of previous attacks of fever, but who have been in contact with typhoid cases, may also harbour the bacilli in their stools. This group of cases is a very important one from the preventive point of view—they form the "bacilli carriers" of the Germans. These persons are in fact "reservoirs" of the bacilli.

3. That the disease may run a very mild course, especially in young children, and hence a number of cases may escape observation. The detection of these cases forms a very important part of the anti-typhoid work.

4. That a disease closely resembling typhoid fever clinically, but caused by a totally distinct organism, *bacillus paratyphosus B.*, may occur at the same time as typhoid fever.

In their anti-typhoid campaign the Germans found it necessary to organise scientific institutions near the typhoid epidemic to enable them to put into practice the principles of investigation and prevention indicated in the above statements. The German Government has founded 11 such institutions, each with a superintendent and two or three trained scientific medical men, as well as one or two attendants, for the anti-typhoid campaign in Alsace-Lorraine. These institutions are fully equipped for the scientific work required. They are chiefly employed in the prevention of the spread of typhoid amongst the civil population. The military population, which is a large one, has a similar organisation, and the conditions being much more favourable for carrying out the anti-typhoid measures, the results show a satisfactory reduction of enteric fever cases amongst the troops.

Basis on which Germany's anti-typhoid campaign is founded.—Koch's work in Alsace and Lorraine was based on the facts that (1) the life of the enteric bacillus outside the human body, whether in earth or soil, is of limited duration; (2) enteric fever cases are the sole origin of enteric bacilli; (3) if all enteric bacilli leaving the human body by the excreta (urine and fæces) were absolutely destroyed, if all persons suffering from enteric fever were completely isolated from all others, the disease would come to an end.

Koch in the investigations connected with his campaign against endemic enteric fever on the South-West Frontier of Germany (Alsace and Lorraine) has shown that the healthy, or at least non-specifically sick, can harbour typhoid bacilli and excrete them to the danger of the public. These bacilli carriers have no symptoms, and are apparently in perfect health. The bacilli are excreted in the fæces and can be demonstrated by ordinary methods. These bacilli carriers are of two classes—the "acute" carriers, who have been in direct contact with enteric cases and excrete the germs of the disease in their fæces for a short time only in small numbers; and the "chronic" carriers, who have a short or a long time before gone through a regular attack of enteric, and may excrete for months pure cultures of the typhoid bacillus. Of 482 cases of typhoid fever kept under bacteriological observation during recovery, 63 were found to excrete the bacillus during convalescence, but only 8 for longer periods than six weeks after the fever subsided, and of these 8 one was excreting bacilli at the end of a year after enteric, the other 7 for periods of from 11 months to 3 months.

Whilst we know that cultures of bacilli of carriers are relatively virulent or pathogenic to guinea pigs, we, of course, do not possess direct proof of their being so to man, but from the epidemiological observations of enteric, the proof is fairly convincing of numerous cases of carriers conveying the disease and starting both sporadic cases and even small epidemics. For practical purposes we may consider that no person can be a carrier unless he has been in contact with an enteric case or has had enteric fever.

Lessons from Koch's campaign against enteric fever in Alsace and Lorraine.—The lessons from these investigations are—

(1) That every case of enteric fever should be kept in hospital, and if necessary under observation, until bacilli are no longer to be discovered in his excreta.

(2) That the urine and fæces should be disinfected and incinerated.

(3) That the hands and parts about the anus and penis should always be disinfected after each evacuation.

To stamp out water-borne epidemics, the prevention is the same as for contact cases—destruction of the virus as it leaves the infected persons in addition to the *sterilisation of all drinking water.*

Enteric prevention includes that of paratyphoid fever.—The remarks made regarding the prevention of typhoid fever include those regarding paratyphoid, in which latter disease the causative microbe is morphologically, culturally, and in other respects nearly identical with that of enteric, the clinical difference being in the milder severity of paratyphoid fever (see p. 504).

Typhoid fever on field service—*Importance of early diagnosis.*—The prompt and early diagnosis of enteric fever cases, and the elimination from the healthy of all persons suffering from symptoms in the least way resembling enteric, is of the utmost importance on field service. The medical officer of units cannot be expected to know of the existence of all such cases at once. But the non-commissioned officers of sections know, or ought to know, everything about their

men, and they should be held responsible that every case with even sight fever or diarrhœa should be sent to hospital at once. When the medical officer sees such a case, he is not likely to allow him to return to the section tent until he has assured himself that the indisposition is of a temporary nature, and when in the least doubtful as regards the diagnosis, he will safeguard his regiment by sending the patient on to a field ambulance.

Isolation of all doubtful cases.—One is inclined to say that every case of fever without obvious cause occurring in European troops on field service should be isolated until its nature is diagnosed, and in doubtful cases, it would be both safer and more judicious, to consider them to be enteric, until such a diagnosis is disproved by the clinical history or other means. Such presumption would, one believes, diminish the foci whence dissemination of the disease occurs.

Complete isolation of developed cases of enteric fever.—In this connection one has no hesitation in recommending that at least two 160 lb. tents should be added to each section of a field ambulance, and 4 for every 100 beds of a general hospital for the isolation of all cases of infectious diseases, such as typhoid fever, dysentery, epidemic diarrhœa, and any other form of communicable disease occurring accidentally; these should form part of the equipment of these hospitals on field service, our arsenals providing condemned tents for this special purpose. One is even disposed to include all cases of pneumonia and malarial fevers in this category, and with regard to the latter, when operating in a malarious country during the endemic malarial season, all cases should be at least provided with mosquito curtains.

As regards enteric medical opinion in some Continental Armies is strongly in favour of such isolation, and in certain military districts in Germany (especially on the South-West Frontier in Alsace-Lorraine) at Professor KOCH'S suggestion, this was carried out with the result of, to some extent, exterminating enteric, while the disease in the civil population of the same districts, without such isolation, continued unabated.

Portable incinerators for excreta of enteric fever and dysentery cases.—On the same principle one would also advocate the addition of at least one portable incinerator for each section of field ambulances, such as are in use in many hospitals in India at present, for the immediate destruction of all excreta from enteric, diarrhœa and dysentery cases, and if necessary, those of cholera; these, however, can usually be improvised from the materials obtainable. To complete these preventive measures it would be necessary to add some readily soluble, inexpensive, portable, coloured disinfectant, for all such excreta, to be used anterior to destruction by heat, *e.g.*, the solution of the perchloride

of mercury soloids, a three months' supply of which soloids, calculated on requiring it for 3 per cent. of the force, might accompany each field ambulance. In general hospitals there will not be the same difficulties to contend with as regards the isolation of such cases, destroying excreta, and preventing the spread of these diseases. In this connection one constantly recalls the state of the field hospitals and their surroundings generally in Karuppa towards the end of our 5 weeks' occupation of that camp in 1897—in the two sections (for 50 beds) of the Native Field Hospital there, we had sometimes over that number of dysentery cases alone, which had to be passed towards the base daily; both medical officers with these sections suffered from acute bacillary (camp) dysentery

Anti-typhoid vaccination.—Sir ALMROTH WRIGHT discovered a method of enhancing the resisting power of the blood against the typhoid bacillus without giving the disease. He found that if the dead germs of typhoid fever are made into a vaccine and injected under the skin, they bring about an immunity to typhoid fever for a time. This process is called *anti-typhoid vaccination*. It is harmless and only causes slight indisposition for from 24 to 48 hours the first time, and for half a day or so the second time it is used. The second injection follows the first at an interval of 8 days. The vaccine now used is simply a culture of the typhoid bacillus grown in broth, killed by heat and with the aid of lysol which acts as a disinfectant; these remove all possibility of any living microbes being inoculated. It is a complete sterile vaccine prepared with the utmost care, standardised with mathematical accuracy, and, on the whole, gives the person inoculated much less worry than an ordinary successful vaccination against small-pox. One has watched the way in which this vaccine is prepared in the Royal Army Medical College, at Millbank, and can assert that there is no possibility of any impurity gaining access to the vaccine at the College. The balance of opinion amongst military medical officers of experience is in favour of anti-typhoid vaccination as a preventive. This remark has special application regarding field service if outbreaks of that disease are for any reason anticipated. The dead bacilli and their products injected in this process undoubtedly react on the blood of the person inoculated in a way to show that his system is prepared to resist the action of the enteric bacillus, if it gains access. Such anti-typhoid vaccination renders those inoculated less susceptible to the disease, and, in the event of their getting enteric, it lessens the chance of the disease ending fatally. The anti-typhoid inoculation committee at home some years ago stated that it was satisfied that the records which were available furnished proof that the practice of anti-typhoid inoculation in the Army had resulted in a substantial reduction in the incidence and death-rate from enteric among the inoculated. In later investigations they express much more positive opinions in its favour. Personally one considers this question to be outside the region of doubt; all evidence is in favour of anti-typhoid vaccination.

The following table, compiled by the Principal Medical Officer, His Majesty's Forces in India, gives the results of anti-typhoid inoculation in 16 British regiments in India and the Colonies and between October 1905 and April 1908 :—

	Inoculated.	Non-inoculated.
Strength	5,473	6,511
Cases of typhoid fever	21	187
Deaths	2	26
Case incidence per 100	3·8	28·3

The inoculated therefore have everything in their favour—they are much less liable to the disease, and if they get it, they have seven times a better chance of recovery than the non-inoculated.

The figures dealt with in those two tables are large, and place the question of the benefits of inoculation beyond all doubt. All men who have not had typhoid fever, should be made to understand these results and the risks they run without inoculation.

Since January 1905, each regiment leaving England for foreign service has had a specially trained medical officer attached to it whose duty is to carry out anti-typhoid inoculations, to verify the diagnosis of enteric fever by modern scientific methods, and to collect statistical information as to the protective effects of the vaccine. Anti-typhoid inoculations are now being carried on as rapidly as is reasonably possible in this country. Up to the 30th September 1910, of a strength of 70,493 European troops in India, no fewer tham 46,448 had been properly inoculated against typhoid, that is, received two or more doses of the vaccine.

Further anti-typhoid inoculation experience.—Over 5,000 German troops going to South-West Africa were inoculated with large doses in increasing activities of anti-typhoid vaccine three times at intervals of 8 days. The vaccine consisted of typhoid bacilli killed at 140° F., protected with 0·3 per cent. of carbolic acid. The disease attacked 424 men, including inoculated and non-inoculated—of the former exactly 100, and of the latter 324. Of the inoculated 30 had been inoculated only once, 52 twice, and 18 three times. Of the non-inoculated 11·1 per cent. died, 25·3 per cent. were severe, 21·3 per cent. of average severity, 42·3 slight. Of the inoculated 4 per cent. died, 3 of the 4 who died had only been inoculated once; 10 per cent. were severe, 20 per cent. average, and 66 per cent. slight (see also p. 404).

All officers should encourage men to be inoculated against typhoid fever. Considering the care and accuracy with which the anti-typhoid vaccine is now prepared, there does not appear to be any reason why all recruits at home, intended for service in India, should not be inoculated in the same way as they are vaccinated against small-pox.

Paratyphoid Fever.

In late years a group of cases of continued fever has been recognised which give rise to the general signs and symptoms of typhoid fever, though much less severe, but in which the serum does not agglutinate the typhoid bacillus. This is called *paratyphoid fever*. The bacillus of this fever has certain characters similar to those of the true typhoid bacillus, and appears to be intermediate between it and the *bacillus coli communis*. This bacillus has been called the *paratyphoid bacillus* (of which there are two varieties A and B) and it is agglutinated by the serum of the cases in which it occurs. The intestinal and other lesions of the disease are not those characteristic of typhoid fever. The disease is seldom fatal, although annually some cases die from it in Europeans troops. It usually occurs sporadically, but it may be epidemic.

Prevention.—The preventive measures are the same as for typhoid fever except that inoculation against it has so far not been practised.

Typhus Fever.

This is an acute specific infectious disease which in its typical form is characterised by sudden commencement, fever which lasts about a fortnight, an eruption of dark spots which may run together and form blotches (patechiæ), marked disturbance of the nervous system, with a tendency to merge into the typhoid state and end by crisis. The disease is met with occasionally throughout India, especially in jails, asylums, and amongst garrison troops and gangs of coolie labourers It occurs chiefly amongst the poorer classes and in the overcrowded and insanitary parts of towns and cities. It is a disease of young adult life, mostly occurring in persons from 25 to 35 years of age, and is highly infectious to all who are brought into intimate contact with the infected patients.

Typhus fever has in bygone periods been a terrible disease in armies. It used to be called *camp, jail, hospital* or *spotted fever*. It is recorded that in the Bavarian Army in 1812, 25,000 of 28,000 men died of it. In the Russo-Turkish War, after the battle of Plevna, half the Russian force of 120,000 men were rendered *hors de combat* by the disease. Typhus fever was common in our Army 50 or 60 years ago, especially at home, but now only occurs occasionally in an epidemic form Its chiefly predisposing cause was overcrowding, uncleanliness of houses and person, and defective diet.

The *period of incubation* averages about 12 days. It is, however, variable; in some cases it has apparently been only a day or two, in others it has extended to about three weeks.

Symptoms.—After the period of incubation there is sudden fever which may be preceded by a shivering fit. The early symptoms are intense headache, nausea and vomiting, pains all over the body, constipation, contracted pupils, furred tongue and much prostration. There is a peculiar mouse-like odour from the patient. Delirium and a heavy dull apathetic appearance are present. The rash appears about the fifth day, first on the abdomen and outer aspects of the hands and wrists. As the fever progresses the "typhoid" state (p.) comes on rapidly, the delirium is now low and muttering, the pupils before contracted are now dilated, there is retention of urine, involuntary opening of the bowels, symptoms of bronchitis or bronchopneumonia set in (but are often hidden by the severity of the disease), and the temperature tends to run higher. If the patient does not succumb, the temperature

falls about the 13th or 14th day, or a few days later, profuse sweating occurs, and diarrhœa, or discharge of urine in large quantities takes place; then the patient gains strength and convalesces speedily. Typhus is distinguished from typhoid fever by the following main characteristics:—

Typhus.	*Typhoid.*
Attacks both sexes and all ages and is usually traceable to infection.	Occurs chiefly in the young, from 15 to 25 years of age, much less frequently after 40. It is during this period that Peyer's patches and the solitary glands (the lymphatic glands in the intestines) are most fully developed; they atrophy as age advances, and after 50 years are comparatively small.
The invasion is sudden; the head symptoms are severe, delirium with contracted pupils usually occurring towards the end of the first week. The eruption which appears as mulberry spots between the 4th and 5th day, does not completely disappear on pressure, and continues as one crop until the fever ends. The rash occurs all over the body. Diarrhœa is seldom present except at the last stage or during the crisis.	The invasion is insidious, the premonitory symptoms lasting about a week. The abdominal organs are much affected; there is diarrhœa, frequently bleeding from the bowels, the abdomen is distended, and pain is felt on pressure. There is low muttering delirium and dilated pupils. The eruption occurs as small slightly elevated rose-coloured papules, less than the size of half a pea. In 2 or 3 days the spots fade away, to appear again in other parts. They disappear on pressure. They are usually scanty but very characteristic.
Typhus prevails most frequently amongst the poor and is a disease of adult life. It is thought to be greatly predisposed to by bad diet and overcrowding. The disease runs its course in from 14 to 21 days and is most dangerous at the end of the second week.	The rich and healthy are often attacked. It is caused by a specific microbe (*bacillus typhosus*). The pollution of drinking water, food, especially milk, by the bacillus is the most frequent cause of the disease.
The cause of the disease is not known.	
Typhus fever is most frequently fatal before the 15th day, never after the 20th. The tendency to death is by coma.	Relapses are common. The fever lasts from 3 to 6 weeks; its maximum intensity is during the third week. It is mostly fatal after the 18th day. The tendency to death is by progressively increasing weakness.

Prevention.—The main points are free ventilation of barracks, houses, and huts, and cleanliness, personal and domestic. Provision of facilities for bathing is indicated. The spread of the disease may to some extent be prevented by isolation and disinfection of those infected, and of everything in their neighbourhood. Those in attendance on the sick should avoid unnecessary contact, as the contagion is more intense in the immediate vicinity of the patient. All attendants should wear a gown or cloak that fastens at the wrists and neck. The clothes worn by the patient immediately before and during the attack are to be thoroughly disinfected. The bedding and furniture of the sick room must also be completely disinfected and finally the room itself. The exclusion of biting flies or vermin may eventually be found to be an important preventive measure.

Epidemic Cerebro-Spinal Fever—"Spotted Fever."

This an acute, specific, infectious, malignant, epidemic and sporadic fever associated with inflammation of the membranes covering the brain and spinal

cord, and is manifested by sudden invasion, high fever, painful contraction of the muscles of the neck and retraction of the head, grave nervous complications and lesions of the brain and spinal cord and their membranes. In certain epidemics it is accompanied with profuse eruptions of dark patches on the surface, and sometimes with effusion into the joints. It is caused by a special microbe, called *meningococcus* (or *diplococus*) *intracellularis meningitidis*.

The disease occurs epidemically and sporadically. It is mainly a disease of young adult life. It is to a limited extent infectious and occasionally possibly contagious through the micro-organism in the nasal secretion. The method of spread of the disease is not definitely known. It is possibly commenced as an epidemic in lower animals. It is greatly predisposed to by insanitary surroundings, starvation and fatigue. The specific microbe occurs in the fluids which bathe the brain and spinal cord, in the blood in about 25 per cent. of the cases, and in the upper respiratory passagos, especially the chambers of the nose. It is often present in the nose in the early stages of the disease. It chiefly occupies certain forms of white blood cells, especially the polymorphonuclear variety (p. 150). It may be cultivated outside the body, is readily stained, and is easily recognised under the microscope.

Symptoms.—The invasion is sudden with a shivering fit; there is intense pain at the back of the head and neck extending down the spine; giddiness, vomiting, delirium, which is succeeded by apathy, and in some cases, by coma. The whole body is very sensitive and may be painful to the touch. The temperature may be but little raised, or be as high as 104 or 106° F. The pulse is variable, and the skin is usually hot. Skin eruptions may appear from the first to the third day, when the patient may temporarily appear to be better. Then the symptoms are aggravated, fever increases and diarrhœa may set in. There may be various localised paralyses, or one side of the body may be paralysed. Exhaustion and emaciation come on rapidly, and the typhoid state is early established, loss of sensation sets in and the patient soon succumbs. If he survives progress towards recovery is very slow.

The eruption of purple patches which sometimes occurs caused the disease to be called "spotted fever." These spots usually begin on the legs, and may involve the whole body.

A considerable number of complications may arise, such as pneumonia, pleurisy, inflammation of the pericardium, pus formations in the joints, disease of the eye, deafness, etc. There is always marked rigidity of the body and a tendency to backward bending of the neck and spine, sudden onset and rapid course, and skin eruptions.

Prevention.—The indications are to maintain cleanliness of person, clothes, bedding; strict attention to the sanitary condition of the barracks or camps and their surroundings, prevention of overcrowding and free ventilation.

Malta Fever.

Synonyms.—Undulant Fever—Mediterranean Fever—Gibraltar Fever.

This is a specific infectious disease characterised by long duration with a series of attacks of irregular undulating fever and intervals of freedom of varying duration, rheumatic-like pains in the joints and limbs, copious sweats, constipation, enlargement of the spleen and frequent relapses. It is due to a special microbe (*micrococcus melitensis*). There is no characteristic rash, but fleeting redness or small sweat pimples or vesicles are common. The disease sets in insidiously.

Malta fever is now known to occur in many stations in India, so far, however, chiefly in Northern India. The order prohibiting the introduction of female goats into all regimental lines has been followed by a reduction in the admissions. The use of the milk of infected goats is the most likely way of acquiring the disease. The disease is not communicable from one person to another directly.

New arrivals in an epidemic area are most liable to it. It attacks mostly those between the ages of 15 and 30 years. It occurs chiefly during the months of July, August and September, but may be met with at any time of the year in this country. One attack gives but short immunity; some authorities even consider that one attack predisposes to future attacks. The mortality is low, 2 per cent. Death may arise from high temperature, heart failure, gradual weakness, or complications. The incubation period is from 2 to 30 days, but usually about 10 to 14 days. There are usually several days during which the patient suffers from headache, loss of appetite, malaise, and sleeplessness, before active symptoms come on.

The microbe of the disease is a small micrococcus which occurs singly or in pairs, is inactive, and has special characters in its method of growth in particular nutrient media. It can live for long periods in the dry state. It agglutinates in the serum of infected persons in high dilutions (1—80 and over). It can be inoculated into monkeys giving rise to the same symptoms as in man. The disease has on several occasions been communicated to man by accidental inoculations of the micrococcus in bacteriological laboratories. The microbe is found in the spleen, liver, kidneys, lymphatic and salivary glands, blood, bile, urine and milk. It does not occur in the expired air, the sweat, saliva or on the surface of the skin. It occurs in very small numbers in the surface blood (from which it may be cultivated), hence the improbability that biting insects are a means of carrying the disease. The urine is the principal means by which the microbe leaves the body. It is also discharged in the fæces. The microbe occurs in large numbers in the spleen. It is a very hardy germ. It can live for 80 days in dust, and in water for a month, but it has never been found naturally in the air, dust, soil or water, and none of these have been found to be concerned in the natural spread of the disease The microbe enters the blood from the alimentary canal through the mucous membrane, and brings about a regular blood-poisoning, which causes enlargement of the spleen.

Whilst the microbe has been found in the stomach of mosquitoes that have fed on persons suffering from the disease, neither these nor any other kind of biting fly have been proved to be capable of disseminating the disease from man to man.

The duration of the disease is variable, but it is usually from 50 to 60 days; it may go on for many months, sometimes for over a year.

The main diagnostic signs are the wavy temperature chart, and the shifting joint affections supplemented by the serum reaction.

Malta fever has to be distinguished from typhoid fever, acute rheumatism, malaria and kala-azar. The serum reaction is a definite means of diagnosis, as the serum agglutinates the micrococcus in dilutions of 1 to 80 readily, and even in 1 to 200 or higher. The agglutination test when properly carried out with a virulent culture of the microbe is reliable when the germs clump in a 1 in 50 dilution of patient's serum within 30 minutes. If negative at first it should be tried on two or three occasions during the disease, as the agglutinating power of the serum varies periodically during the course of the disease.

Personally, one is convinced that Malta fever is much more prevalent in India than is generally considered to be the case, and it is necessary to be on the lookout for it in all places where goat's milk is used.

Since July 1906 goat's milk has not been issued to troops in Malta, with the result that the cases of Malta fever have dropped to less than one-twelfth of what they were previously, and the latest statistics indicate that the disease has been practically eradicated from troops in Malta (see p. 187).

The only preventive measure necessary is the avoidance of goat's milk, or, at least, the complete sterilisation of it by boiling before use. Female goats should not be allowed in regimental lines.

Influenza.

Influenza is an acute specific infectious disease, characterised by fever and symptoms mainly affecting the respiratory, digestive or nervous systems, and by prolonged prostration during convalescence. Epidemics are most frequent in winter when respiratory diseases are most prevalent. Adults between 20 and 40 years of age are the most susceptible, young and very old people are less often attacked. Sedentary occupations predispose to it.

The disease is caused by a very small rod-shaped bacillus (*bacillus influenzæ*) which is motionless, and occurs singly, in pairs, and short chains. It is found in the phlegm coughed up, it may sometimes be found *post-mortem* in other parts, such as the heart, nervous system, etc., and occasionally in the blood. The infection is conveyed in the secretions of the nose and lungs. The period of incubation is from a few hours to six days.

Symptoms.—The onset is sudden, sometimes beginning with a chill or shivering fit. There are frontal headache and backache, pains in the bones and muscles, weakness, lassitude and unaccountable depression, physical and mental. The temperature rises rapidly to 102 or even 104°F., but is often irregular and may run higher; the skin is hot and dry, there is running from the eyes and nose, and symptoms of bronchitis with some difficulty in breathing, the upper part of the air tubes usually being attacked. There is generally more or less irritation or inflammation of the nose and throat. Bleeding from the nose is not uncommon. There is general soreness of the muscles of the back and limbs and complete loss of appetite. The pulse is weak, tongue coated, the bowels usually constipated, urine scanty and high coloured, or profuse and lighter coloured than normal.

In mild cases convalescence sets in after a couple of days, but leaves a feeling of considerable prostration for some time. In more severe cases after the first few days the disease may assume one of three types: (1) *Respiratory* or *catarrhal type*, in which the chief symptoms are those of inflammation of the respiratory tract, especially bronchitis or pneumonia; (2) *Gastro-intestinal* or *abdominal type*, in which disturbance of the digestive tract is most marked; there is pain at the pit of the stomach, vomiting and sometimes jaundice (some of these cases simulate severe typhoid fever with a sudden onset); (3) *Nervous* or *cerebral type*, in which disturbances of the nervous system predominate, and which closely simulate a certain form of typhoid fever; the initial pains are more severe, and after the disease abates, the heart becomes slowed, or irregular, and there are sometimes severe paroxysmal pain over the heart and great depression. In some cases there may be delirium or coma.

Cases running an uncomplicated course usually get better; in old people the disease may be fatal, usually from pneumonia. Relapses are common.

In the catarrhal type there is sneezing and symptoms of a severe cold in the head, watering of the eyes, breathing somewhat difficult with a tearing irritative cough, later the cough is freer, and there is a thick glairy phlegm discharged, sometime

with streaks of blood; the nasal secretion becomes thicker; with recovery there is often a profuse watery diarrhœa. Occasionally there is tonsillitis.

In what is known as the *typhoid type* the course of the disease may be prolonged and the temperature continue high; the prostration is extreme.

In all types the action of the heart may be very feeble and heart failure is always a threatening danger. In the course of the disease one of many complications may arise, such as nervous disorders, neuritis, neuralgia, hæmorrhages from mucous passages, disease of the kidneys, heart complications, pus-formation in joints, etc.

The duration of influenza is variable. It may last less than 48 hours, or continue for weeks. Usually the acute symptoms last for 3 or 4 days to a week, but the weakness and depression continue much longer. Convalescence may be tardy, the temperature may be below normal for some weeks, and there may be free perspiration especially on exertion.

Prevention.—The possibility of *influenza* occurring in a field force is not to be lost sight of, as it may be a serious cause for delaying military operations. Hitherto preventive measures have practically failed under all circumstances, and except in the earlier cases, under the conditions in which our Indian Army are encamped on field service, it is practically hopeless to attempt them. There is no known method of preventing the spread of this disease, although a ten-grain dose of quinine is recommended by some authorities. It is obviously necessary to send every case to hospital as soon as any signs of the disease appear.

Dengue.

Synonyms.—Break-bone Fever—Dandy Fever.

Dengue is an acute epidemic specific and infectious disease characterised by fever, severe pains in the bones, joints and muscles, and subsequently by an eruption. The period of incubation is from 3 to 5 or 6 days. The invasion is sudden with high fever (104° to 106° F.), the joints being swollen and reddened. After the fever has lasted 3 or 4 days it subsides; but at the end of from 2 to 4 days a second paroxysm accompanied with fever occurs. Convalescence is slow, but complications are rare.

It is endemic in certain low-lying districts such as those of lower Bengal; it becomes epidemic and spreads like influenza over vast areas, diffusing rapidly along the lines of commerce and travel, and its undoubted transmission from person to person in some way to regions not previously infected, stamps it as an infectious disease. The disease as usually seen occurs epidemically and is highly infectious, and once it appears in a cantonment practically every man gets it. It may occur twice or oftener in the same person; the immunity acquired by each attack is of comparatively short duration. The specific cause of the disease has so far not been discovered. A specific bacillus has on but slight evidence been associated with it, and both *Culex fatigans* and *Stegomyia calopus* have been incriminated as carriers of it. There is much evidence to support the view that *Culex fatigans* is capable of spreading the disease from man to man. The fact that the disease has been limited to geographical regions in which this mosquito thrives is significant in this respect. When the blood of an infected person is injected into the veins of a healthy person, the latter gets the disease.

Prevention.—The dissemination of the disease cannot be prevented by any known agency. At one time full doses of quinine were advocated as a prophylactic, but they have been proved to be useless. The short period of immunity acquired by an attack indicates that it arises from an antitoxin that does not last long in the

body. The disease is so infectious that neither local nor general segregation of the infected is of any avail. In view of the possibility of *Culex fatigans* disseminating the disease, the use of mosquito-nets, both by the infected and healthy, is indicated during epidemics of the disease. Very widespread epidemics of dengue have appeared in the Army in India, usually after intervals of many years, that of 1871-72 having passed through the whole continent of India.

Plague.

Synonyms.—Pestis—Bubonic Plague.

Plague is an acute specific infectious disease characterised by rapidity of onset and course, great virulence, fever, great constitutional disturbance, extreme depression, accompanied by buboes, or inflammation of the lungs, or blood-poisoning ; it is due to the presence in the internal organs, blood and tissues, of a special bacillus (*bacillus pestis*). The disease attacks all ages and both sexes.

Plague in an epidemic form has continued in this country since 1896, and, notwithstanding every practicable effort to stamp it out, continues more or less unabated in various parts of India. During the last 14 years in India it has been one of the greatest scourges that has ever occurred in the history of disease in modern times.

It still continues to kill off from 3,000 to 5,000 persons every week. The present epidemic of the disease actually began in the Yunnan Province of China about 1890, spread through China, then to Hong-Kong and India, reaching Bombay in 1896 and Calcutta in 1897. Plague has occurred epidemically for many years in Kula and in the Kurram Valley. In its epidemic centres rats and other animals are known to die of plague, and rats specially are one of the means of carrying the disease from place to place both by land and sea.

Plague has in the past travelled with armies and led to great mortality. Our European troops have been practically free from plague. Those who have got it have usually been infected while on duty in plague infected places, or have acquired the disease in infected towns, villages or bazaars. Considering that our Native troops are quartered in many places in which plague has existed more or less epidemically for years, the number of cases that occur are comparatively small. The conditions of life in barracks are not such as foster the dissemination of this particular disease.

Overcrowding, defective ventilation, insanitary surroundings, and insufficient or defective diet, are its main predisposing causes.

The essential cause of plague is a specific bacillus (which has responded to all the tests required to prove that a microbe is the cause of the disease, p. 412). The bacillus grows rapidly in the blood and internal organs of rats, and when it spreads amongst them produces what is called an *epizootic*, which corresponds to an epidemic in man. There is very strong proof that it is through rats that plague is spread to man. Rats feed on the bodies of other rats that have died of plague, or on food which has been specifically contaminated and then they get it themselves; they are, however, chiefly infected through their own fleas. The fleas coming from rats suffering from plague are instrumental in giving the disease to man. Before and during an epidemic outbreak of plague in a town or village, a great number of rats die, and if the blood and internal organs of these rats are examined, they are found to be crowded with plague bacilli.

The plague bacillus brings about a natural epizootic in rats; this is the real disease, which affects man secondarily. There are many species of fleas; each species is parasitic in particular animals, but when that animal dies or is not in the neighbourhood, the fleas feed vicariously on other mammalia. The chief rat flea which carries plague from rats to man is *Pulex cheopis*.

Atmospheric temperature has little effect on the breeding of fleas, but excessive moisture and dampness damages the flea, kills the larvæ, and interferes with development. Young fleas after being hatched out can live for a week or two without a feed of blood, and then if it does not feed, it dies. Infection by the plague bacillus does not affect the health of the flea as far as we know. The flea selects the spot it is going to bite, then pierces it with the labrum, making a hole which the mandibles enlarge; through grooves which are contained in the mandibles it pumps saliva into the skin. The saliva irritates and dilates the blood vessels, and from them the blood is sucked up a tube formed by the union of the mandibles with the labrum, this tube being in the skin while the suction is going on. Through the wound so made the bacilli are inoculated.

There are several species of rats in India, all of which are very susceptible to plague. The two chief rats concerned in plague in this country are *Mus rattus* and *Mus decumanus*. The *Mus rattus* is a slender rat with a pointed snout, large projecting ears, prominent large eyes, greyish-black coat, and long tail. This is the black rat. The tail is brownish in colour, regularly ringed, and is much longer than all the rest of the animal. The colour, of the body varies. It is essentially a domestic rat, living in thatch or tiles of the roof, in holes and excavations or spaces in the floor, and in certain trees such as the cocoanut. The *Mus decumanus* is a large, heavy-looking rat, with a tapering tail, brown on the back, dirty white on the belly, flesh-coloured feet, round short ears, and a broad heavy muzzle. This is the brown sewer rat, and the one which invades the grain cargoes of ships. It is the real plague rat of Bombay, it is very prolific, giving several litters of from 8 to 10 yearly. The infection in Bombay first rises in the *Mus decumanus* and ten days later in the *Mus rattus*, showing that the disease was acquired by the latter from the former. There are usually only about half as many fleas on the latter. But it is from the fleas of the *Mus rattus* that man chiefly acquires the infection on account of its domestic habits. The epizootic begins to rise about 12 days before the disease occurs epidemically in man. "This period is calculated to be made up of 3 days during which the flea leaves the dead rat, to which is added another 3 days which is the incubation period of plague in man, and 5½ days, which is the average duration of the fatal illness in man" (CASTELLANI and CHAMBERS).

As soon as the epidemic occurs amongst rats, the healthy ones leave the infected. The fleas also desert the dead and dying rats, and seek some vicarious host. As the black rat dwells near man, if the epidemic is amongst them, fleas from them attack man and then an epidemic is commenced. If the epidemic is amongst brown rats

the chances of infection are considerably less. The fact that infected fleas communicate the disease from rat to rat is now beyond all doubt, and this is not limited to the ordinary form of the rat flea, but may also be communicated through the dog flea and fleas of other animals. There are several cases on record also which appear to indicate that infected rat fleas could have been the only way the disease was communicated to man. Direct communication of the disease to various animals by specifically infected fleas has been carried out repeatedly under the most carefully conducted experiments.

Infection in man occurs through (1) the breathing channels giving rise chiefly to *pneumonic plague*, which is highly infectious directly from person to person; (2) through the alimentary canal, probably the method of origin of the very dangerous form called *septicæmic plague*; (3) by flea bites and very seldom abrasions or cracks or wounds on the skin causing *bubonic plague*. *Bubonic plague*, by far the commonest form, is usually conveyed through rat fleas, or by direct inoculation of bacilli into some broken surface of the skin. Bubonic plague is probably also disseminated by clothes infected with discharges from plague patients. The bacilli may gain entrance to the blood-vessels through damage to the walls in the veins in the primary bubo, and this may give rise to the septicæmic form of the disease and further bubonic enlargements. The microbe leaves the body by the expectoration and to a less extent by other excreta; the pus in the swellings of bubonic plague contains the germ in almost pure culture. Whilst pneumonic plague is decidedly infectious, the other forms of the disease are not readily transmitted directly from the infected to the healthy. We know that infection is derived from some source outside the body, but it is probable that the soil of infected areas is only occasionally, if at all, responsible for its spread. It is well known that the microbe may be conveyed from place to place by clothes and merchandise, as well as through rats.

Bacillus pestis.—The bacillus of the disease is quite characteristic. It is a comparatively short rod-shaped microbe, with a thick body and rounded ends, is

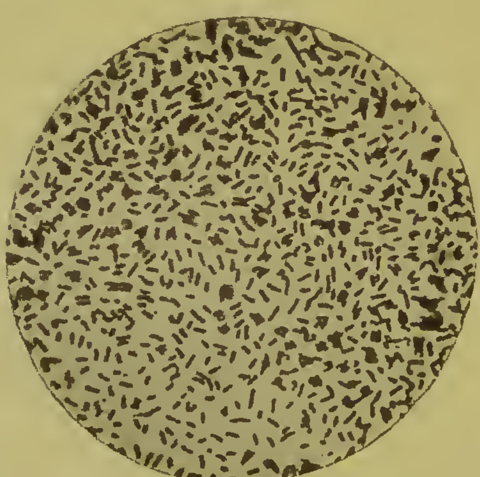

FIG. 82.—Plague bacilli.

motionless, has one or two flagella, and presents characteristic staining at both ends under the microscope. It is very easily detected in stained preparations of bubo pus, phlegm from the lungs, and in certain cases from the blood. It is also characterised by the fact that if it is grown in peptone broth made slightly alkaline and covered with *ghee*, in about a week colonies of the bacillus will form stalactitic growths from the under-surface of the layer of *ghee*. The bacillus of plague is killed by exposure to the direct sunlight for half an hour, by heating to 176° F. for 5 minutes, and is readily killed by ordinary disinfectants. It, however, resists cold, and may be frozen for months without injury.

All forms of insanitation, accumulations of filth near houses, bad conservancy arrangements in towns, overcrowding of houses and areas, and want of ventilation, are potent factors in assisting plague to locate itself in cities and towns. This has been well shown in the comparative exemption of persons dwellings in the midst of epidemic plague, but who live healthy lives amidst good hygienic surroundings. The dirtier and more insanitary parts of a town are actively attacked, whilst the cleaner and more sanitary places usually escape. Doctors and nurses, who are clean in their habits, rarely get the disease from plague patients, especially when the hospitals they work in are well ventilated. Good sanitary state of the house and surroundings as being opposed to rats and rat fleas, and the reverse in insanitary places, explains the occurrence of the disease in certain quarters of towns and cities and the exemption of others. Europeans living under insanitary conditions in epidemic areas acquire the disease quite as readily as indigenous inhabitants. Plague is comparatively slow in invading new centres, yet once it has established itself in a place it is very difficult to eradicate.

Symptoms.—With plague there are rarely any premonitory symptoms. The onset is sudden; there is sometimes a short sharp shivering fit. The temperature rises rapidly, the face is flushed, the eyes are red, the expression anxious, the patient often having a dazed and frightened look; there is vomiting, headache, the gait is reeling or staggering like that of a drunken man, and there is a great tendency for the patient to wander from his bed. The speech is thick, indistinct and peculiar, the tongue is swollen, thickly coated with a white fur, dry, and red at the tip and edges; the headache is severe and frontal, the pulse frequent and full but very compressible. There is great depression. There may be constipation or diarrhœa.

Bubonic plague.—The temperature rises rapidly attaining its maximum on the third day, and there is frequently early delirium. The patient gets into a very low condition and death often occurs about this time. In from 2 to 8 days from the beginning of the symptoms a lymphatic gland, or series of glands in the groin, neck, or armpit enlarges rapidly, is painful and extremely tender. The buboes are most common in the groin and upper part of the front of the thigh, less common in the armpits, least common below the angle of the jaw. They are usually large and come singly, and the skin over them is inflamed. The patient becomes weaker, an apathetic condition arises, he is unable to speak distinctly, often leaving out syllables of words, the face is dusky, and delirium may now set in for the first time. The urine is greatly lessened in quantity. Now the temperature may begin to drop, the pulse improve, and the fever may disappear by the 7th or 8th day. If the temperature does not go down below 100° F., it is possible that the bacillus has got into the blood, or that some complication has arisen. Or, the temperature may suddenly drop and the patient die from heart failure. In bubonic plague convalescence occurs from the 6th to 10th day, but the bubo goes on enlarging, breaks down, and is discharged in the form of pus and sloughs which may go on for weeks. In the ordinary form of bubonic plague

the bacillus is not found in the surface blood till just before death. The same is the case with pneumonic plague. In septicæmic cases the bacillus is found in the finger blood from the beginning. In all cases the number of white cells in the blood is markedly increased.

Pneumonic plague.—In this type the initial features are the same as those of the bubonic variety; instead, however, of a bubo making its appearance, the breathing becomes accelerated and accompanied by a cough, the sputum is reddish and copious and contains myriads of plague bacilli in pure culture. There are all the signs of patchy pneumonia over both lungs. It is a very fatal form of plague, death occurring on the third or fourth day. It is highly infectious.

Septicæmic plague.—This is a virulent type of the disease due to the invasion of the blood by plague bacilli in great numbers. The general symptoms are in the main the same as those of bubonic plague. There are no buboes, but *post-mortem* all the lymphatic glands are found to be swollen and inflamed. The bacilli are readily found in the blood. It sets in rapidly, is associated with symptoms of profound blood-poisoning and great nervous prostration—delirium, stupor or great restlessness. There may be involuntary evacuations of the bowels, bleeding from the nose, kidneys or bowels. If the patient lives to the fourth or fifth day buboes may appear.

Ambulatory plague or *Pestis minor.*—Some cases of plague are very mild, so much so that the patient is able to walk about, and in doing so diffuses the disease amongst the healthy—this is ambulatory plague or *pestis minor*. In it there is usually the painful enlargement of one of the glands in the groin, slight constitutional disturbance, the temperature rises to 100° or 101° F., and recovery begins in two or three days; sometimes these cases begin an epidemic or may succeed a severe epidemic that is dying out. These cases are a grave source of danger in any community, as they are unnoticed, yet spread the disease. During convalescence there is great prostration for some time.

After recovery from all types of plague the patient may suffer from weakness of the heart with attacks of fainting, paralysis of muscles, septic infections, gangrene of the lungs, etc.; the spleen and kidneys are enlarged and often the liver also.

The mortality varies in different epidemics; in the usual bubonic form it is 70 per cent. amongst natives and 20 per cent. amongst Europeans. Septicæmic and pneumonic plague are almost always fatal.

Prevention.—The special public preventive measures to be taken include—the discovery of all early cases, establishment of a plague hospital, segregation of the infected, isolation of all "contacts," disinfection, destruction of rats, compulsory notification of cases, prophylactic inoculation, and proper disposal of the dead. Every possible means should be adopted to discover all cases of ambulatory plague and slight attacks of the disease, and cases of pneumonia and "fever" occurring in the same neighbourhood—in all probability some of these latter are plague. To do this properly barrack to barrack, house to house, or hut to hut visitation may be necessary. In all cases of doubt a bacteriological

examination of phlegm, blood and matter extracted from buboes should be carried out. Rigorous isolation of patients should be carried out and continued for a month after recovery.

Segregation and Disinfection.—All cases in cantonments should when possible be treated in a permanent or temporary infectious diseases hospital. The question as to the advisability of moving the rest of the infected regiment into camp may have to be seriously considered, if only for a brief period to permit of thorough disinfection of the area and the destruction of all rats. Sick attendants should be inoculated with anti-plague vaccine. Similarly all persons living in an infected barrack, house or hut should be inoculated. The *excreta* of the patients, their clothes, and the utensils used, the attendants on the sick and their clothes, and the room, house or hut in which the case or cases occurred, are all to be thoroughly disinfected. In this the action of sunlight and exposure of the area, if necessary by unroofing, and free ventilation, are important. The plague bacillus is killed with corrosive sublimate solution (1—1,000), carbolic acid solution (1—100), and permanganate of potassium (1—50,000). Clothes may be disinfected by boiling for half an hour or by means of steam (p. 425). All barracks, houses and huts that have been occupied by plague patients should be avoided. It is particularly necessary to avoid walking in bare feet in dwellings that are infected. Flushing of streets and roads with chloride of lime solution (1 pound to 10 gallons of water) is useful in infected areas, and special attention should be given to disinfection of drains and latrines. One of the most important things to do in a plague-smitten cantonment is to kill all the rats possible in it. The destruction of rats on a large or a small scale may theoretically appear to be an easily accomplished task, but in actual practice it is extremely difficult. Rats like all smaller animals have natural enemies such as cats, owls, etc., but under ordinary circumstances these do not reduce their numbers. The most practical methods of reducing them are by means of rat traps, cats, rat poisons, and the employment of microbes that are destructive to rats but harmless to other animals. On a small scale, when vigorously used, these methods are successful, but, except in the last named, they take some time to operate in a generalised campaign against rats. There are two or three special bacilli in use at present for disseminating destructive disease amongst rats, and that most in use in India is DANYZ bacillus (probably the *Bacillus typhi murium*), which is the cause of an epidemic disease amongst harvest mice in some years in Europe. It has been largely used in India, but the results have not been satisfactory, as it has been found that it rapidly loses it virulence in this country. Rats may also be destroyed in barracks, houses and huts by means of sulphur dioxide gas diffused through the Clayton apparatus (p. 427). The destruction of rats by cantonment authorities is a public health measure that should be legislated for in plague-stricken areas. Destruction of rats should be carried out in anticipation of plague

especially where it is likely to occur. If rats are exterminated before the plague is imported, there should be little difficulty in preventing its spread. As soon as dead rats are found they should be incinerated, and the houses in which they were found disinfected. The excreta of infected rats are crowded with plague bacilli. All conditions favourable to the existence of rats should be removed, and as far as practicable their exclusion from houses effected. The most scrupulous cleanliness of persons, of all individual houses and their surroundings, and of streets, together with the best *ventilation* and *abundance of light* are the most reliable measures for stopping the spread of the disease. A house kept in a state of sanitary cleanliness and well ventilated, well lighted, on a dry site and free from rats, is not likely to become a plague focus.

Compulsory notification.—This is an imperative duty (see p. 405). Strict watch should be kept on all natives employed in the lines, especially on servants and hawkers.

Disposal of the dead.—The body should be washed with a 1--1,000 corrosive sublimate solution, wrapped in one or more sheets saturated with the same solution and preferably cremated (see p. 436).

Haffkine's prophylactic vaccine.—This consists of a broth and *ghee* culture of the bacillus of plague which is killed by heat and then sterilised by the use of carbolic acid. A six weeks' old cultivation of the bacillus is heated for an hour at 158° F. About 150 minims of this vaccine is injected under the skin. It gives rise to slight fever (100° F. or so), slight headache, and discomfort, lasting 36 hours. This vaccine is so standardised that we know almost exactly how many of the germs are inoculated with each dose of the vaccine. It gives healthy people protection for from 7 to 9 months. If used during the incubation period it sometimes aborts the disease. In an endemic area the percentage of recoveries in those inoculated is much higher than those not. Haffkine's anti-plague vaccination has been successfully employed on a large scale in India, it has reduced the number of cases and considerably lessened the death-rate in those inoculated. Of 2,197 persons inoculated out of a population of 6,033 in an epidemic area, only 30 died of plague, while of the non-inoculated 1,482 died, a difference of 82 per cent. in favour of inoculation. With reference to the effects of anti-plague vaccination, the following statement is abstracted from an official report of plague in the Punjab for the year 1904:—"Among 639,630 non-inoculated, 49,433 (or 7·7 per cent.) cases occurred with 29,733 (or 4·7 per cent.) deaths; among 186,797 inoculated 3,399 cases (1·8 per cent.) occurred with 814 (0·4 per cent.) deaths The number of cases was thus reduced to less than one-fourth, the proportion of deaths to cases to less than one-half, and the total death-rate from plague to less than one-tenth of what it was amongst the non-inoculated." It is probable that the minimising effects of the vaccine begin very rapidly, and HAFFKINE considers that it may arrest

the incubating disease, or favourably influence its progress, in persons already infected. He is of opinion that the European race is physiologically less sensitive to plague than are the people of India, and he is inclined to believe that possibly this is the reason why protection conferred by inoculation is higher and more lasting in the European.*

If living in a plague district, it is advisable to get inoculated against the disease. In such a district any one is liable to accidental exposure to infection by plague bacilli, either through infected clothes, infected places or infected persons. Nurses, nursing and ward orderlies working amongst plague cases should always be inoculated. They should be scrupulously careful as to cleanliness of their hands when on duty, never take their meals in the patient's room, and take regular airing for a few hours every day.

In plague areas all bazaars and towns should be placed out of bounds—men, both European troops and Native troops, and followers should be prohibited from going to infected areas and furlough to such areas should be stopped while the disease continues.

Plague on field service.—The possibility of *plague* on field service should not be forgotten, although it is not likely to affect a well-controlled army under discipline, even when moving in an infected country. The exemption of armies in the field from this scourge of civil life in India, may be explained by the absence from camps of the chief disseminator of the disease—the rat flea. If the disease is prevalent in the civil community, however, and such a country must be invaded, the question as to the advisability of the general use of anti-plague vaccination of all ranks will have been considered by the command authorities. There is abundant evidence that inoculation of this vaccine lessens the chance of getting the disease, that if acquired, it is less severe, and it considerably lessens the chance of the person inoculated dying from the disease.

SMALL-POX—VARIOLA.

Small-pox is an acute, contagious, infectious and specific disease which sets in with severe fever, headache, pain in the back, vomiting and more or less prostration, followed by an eruption, which at first consists of papules, these become vesicles and finally pustules; there is a distinct remission of the fever when the eruption appears, and this remission continues until the pustules form. The pustules dry up and form scabs which fall off about the 20th day of the disease, and leave a pitted appearance of the skin (pock-marks). The fever is produced by an unknown microbe that manufactures toxins which are very depressing in their effects, and open the way for infection of the tissues by other microbes which cause the secondary fever.

* W. M. HAFFKINE, C.I.E., *Bulletin de l'Institut Pasteur*, October 30, 1908.

The infectious material exists in the secretions, excretions, pustules, and probably in exhalations from the lungs; the skin conveys it through the medium of the eruption. The infectious element of the disease is difficult to destroy and remains active for long periods. Hence the urgent necessity of the very radical measures that are necessary in the disinfection of barracks, houses and huts that have become infected.

The disease may be conveyed through the air for some distance, certainly several hundred yards. It is probable that flies and vermin may convey the disease. The patient ceases to be infective only when the last bit of desquamating skin has been removed. The severity of the disease bears no relation to that of the case from which it is acquired

In 1909 there were 156 admissions for small-pox in the Army in India as compared with only 62 in 1908. It is almost impossible to improve on our present method of vaccination and re-vaccination. The cases of small-pox that occur in practically all regiments are sporadic, showing that the disease cannot at present lay hold of men properly protected by vaccination and revaccination.

The infective agent of small-pox has not been discovered. Whatever its nature, it is contained in the pustules. The poison lasts unimpaired in its virulence in the scales and scabs, and by their disintegration there is no doubt that an infective dust may arise. The body of a person dead of small-pox is infective for several days at least.

The poison is very persistent and tenacious, and can be conveyed by clothes, bedding, carpets, curtains, screens and furniture that have been in the same room as an infected person, and it may be conveyed in the clothes of healthy persons who have been in contact with small-pox cases. The neighbourhood of *dhobies'* huts is dangerous when small-pox is prevalent. It is apt to be spread at the outset of epidemics by patients who have a modified attack, and it often happens that homeless persons carry infection from place to place, and into lodging houses and huts; public premises and conveyances may also be thus infected. When small-pox patients are collected in hospital, air-currents often seem to transmit the disease for a quarter of a mile or more. At the same time it is very difficult to eliminate entirely the possibility of transference in other ways. Second attacks of small-pox are rare, third attacks are exceedingly so.

No disease is so preventable as small-pox. This very preventability is one of the greatest triumphs of the medical art. There are now many instances recorded in which it has been almost entirely stamped out in large communities by vaccination properly carried out (see p. 521). It may be said that its existence, to any extent in a civilised nation, is a blemish upon that nation.

Small pox is almost always present in some part of India. It is worshipped in the form of a goddess by certain classes of Hindoos. Inoculation for this affection has been carried on for two thousand years, and is still in Nepaul and by certain hill tribes of the Himalayas. Wherever small-pox occurs and vaccination is not practised, the disease becomes a most loathsome and fatal scourge. It is the most contagious and infectious disease known.

The incubation period of small-pox is about 12 days on an average, but it may vary from 8 to 14 days. During this time there are practically no symptoms.

Varieties.—There are several varieties of small-pox—*discrete*, in which the vesicles remain separate on the face; *confluent*, in which they run into one another on the face; *semi-confluent*, midway between these two; and *hæmorrhagic* (the most dangerous form) in which the vesicles, or what would have been vesicles, are filled with blood.

Symptoms.—The invasion is sudden with a shivering fit, severe frontal headache, pain the back, and fever. The temperature runs up rapidly with all the phenomena of fever. On the third day the fever usually abates and the rash appears as papules. At the end of a week from the commencement the symptoms become worse and more pronounced than before, the fever increases, and on the ninth day when the rash becomes pustular, the *secondary fever* occurs, which is due to toxins absorbed from the pustules and those of septic germs. The fever is now of a septic type—the temperature oscillates. There may be shivering fits and great prostration. There is great swelling of the face, and the eyes may be closed up. There is usually some soreness of the throat. The patient is now usually in a dangerous state. If he rallies, the temperature subsides and the pustules begin to dry up.

The *eruption* first appears on the third day of the fever, on the face, forehead and scalp, as slightly raised red papules, which feel like small shot under the skin. It subsequently appears on the backs of the wrists and arms, and lastly on the legs. The mucous membranes of the air passages, alimentary canal, etc., are also affected. Three days later (on the sixth day of the fever), the papules become vesicles, the contents of which are first clear and transparent, and then turbid, and each has a depression in the middle. Each vesicle is also divided into a number of tiny compartments by partitions of delicate tissue. Usually about five days later (eighth day of the eruption) the vesicle becomes purulent, accompanied with an inflammatory ring around each vesicle which causes great swelling and disfigurement of the parts affected, and this is attended with a return of the fever and exacerbation of the symptoms, then the pustules begin to dry; a blackish-brown scab forms and drops off leaving a depressed scar. Usually by the 14th day from the commencement of the fever the pustules are beginning to dry up and in from three to four weeks all the scabs have fallen off. The rash is seen on the mucous membrane of the mouth, tongue, soft palate and pharynx, going through the same phases as that of the skin. In the larynx and bronchial tubes it may give rise to much cough, in the stomach to severe vomiting, and in the bowels to diarrhœa.

In *confluent small-pox* all the symptoms are intensified, and in the stage of pustulation the patient presents a frightful appearance, and there is a foul and characteristic odour. The face is a swollen and unrecognisable mass of fœtid sores, though on the body and legs the eruption often remains discrete.

In *hæmorrhagic* (*black*) *small pox*, the vesicles are all black, and give the patient a terrible appearance. In some cases bleeding occurs from any or all of the mucous membranes, and death may occur in from three to four days after the onset of the hæmorrhagic symptoms.

A *malignant* form of *small-pox* is also met with characterised by low fever, scant or absent eruption, profound prostration, and a fatal issue with or without hæmorrhage between the third and seventh day.

Modified small-pox (Varioloid) is an attenuated form of the disease, modified by vaccination or by natural immunity from a previous attack. It differs from the ordinary form of the disease by its short duration, the irregular or incomplete eruption (which runs a rapid course), absence of any marked secondary fever, and the early completion of desquamation. The initial symptoms are usually, but not necessarily, mild, and the eruption may or may not be limited to the face and hands. The characteristic initial symptoms of small-pox are present, the disease running a milder course.

In the presence of an epidemic, cases presenting severe pain in the head and back with vomiting and fever, must be looked on with suspicion, and in association with the peculiarly located initial rash, the disease may as a rule be diagnosed. The typical eruption is unmistakable, appearing on the third day; the course of the fever characteristic—being primarily high and dropping to normal, or in more severe cases, to 100° F. or 100·5° F. only, to reappear with pustulation.

Prevention of small-pox.—Small-pox occurs in severe and widespread epidemics in some parts of this country, almost every year, and it is desirable for us to know what steps should be adopted to prevent its spread in a community. The chief means to be adopted are—compulsory notification, isolation, disinfection, and vaccination and re-vaccination of all unprotected persons.

1. Compulsory notification.—This means that it is compulsory for all persons who know of a case of small-pox in existence in a cantonment to make it known to the cantonment authorities, sanitary officer, senior medical officer, principal medical officer and other officials concerned. This is a duty that every person owes to himself and to other persons of the cantonment This applies not only to small-pox but to every infectious or communicable disease. By carrying out compulsory notification completely, every case of small-pox that occurs is brought to notice of the sanitary and other officials, who at once take steps to prevent its dissemination in the community. These authorities see that the patient is isolated, and, if necessary, properly treated in a suitable hospital (p. 405).

2. Isolation.—All cases of small-pox should be isolated, that is, separated from healthy persons. This may be done in a proper temporary or permanent infectious diseases hospital (p. 403). In large cantonments where the patient is taken to an infectious diseases hospital, he is removed in a special ambulance along the most unfrequented roads, and the later this is done at night the fewer healthy persons are met. All large cantonments should at least be provided with closed comfortable ambulances for transporting cases to the infectious diseases hospital. Public and private vehicles should not be used for this purpose.

3. Disinfection.—Disinfection of the infected barrack, house or hut is urgently required in small-pox. This is to be done under the supervision of a medical or other official, who directs that all clothes

and loose articles are to be suspended in the infected room, all doors and windows be closed, all chimneys and chinks are blocked up and then fumigates all the rooms in the house with sulphur dioxide for several hours, 4 pounds of sulphur being required for every 1,000 cubic feet of air space (p. 427). It is, however, safer to burn all clothes, bedding, matting or *chattai*, etc., that have been in contact with the patient. The clothes of all persons who have attended the patient should be soaked in some powerful disinfectant, and the floor, walls, beds and chairs, etc., are to be carefully washed with a disinfectant. If there is wall paper in the rooms this should be removed and burnt, and the walls thoroughly washed with some disinfectant (see p. 433). Every barrack, hut, or house in which a case of small-pox has occurred and those in the neighbourhood should be kept under daily observation for about a fortnight or three weeks, to detect fresh cases at once should they arise.

4. **Vaccination—Re-vaccination.**—All persons living in the barrack, house, or hut, and in the neighbouring barracks, houses or huts should be vaccinated or re-vaccinated, so that a circle of persons protected from small-pox is rendered immune by vaccination, and so on, as each fresh case occurs in other barracks, houses or huts. When a case of small-pox occurs in a family it is a sound rule to vaccinate all the other members of the family at once.

There is no scientific fact better established than that vaccination properly carried out in infancy and repeated once or twice during after-life, is capable of effectually preventing the occurrence of small-pox in communities. Theoretically, therefore, it appears easy to control the disease and even eradicate it, but in practice over a large country like India there are difficulties in the way of accomplishing this completely that may be considered unsurmountable. If efficient vaccination were carried out universally no other preventive measure would be necessary.

Vaccination.—*Vaccination* is now practically always done with glycerinated calf lymph. The calves are vaccinated with strict *aseptic* precautions on the shaved abdomen. The resulting lymph is collected and mixed with chemically pure glycerine, and is then allowed to stand for four weeks, during which time all bacteria that may have got into the lymph accidentally are destroyed, while the activity of the lymph is not only not impaired, but improved. When this glycerinated lymph is proved by microscopic examination or otherwise to be bacteriologically pure, it is sent out from the vaccine depôts in capillary glass tubes, and should be used within a fortnight as its power gradually lessens and is lost in from a month to six weeks.

This is the kind of lymph that is manufactured in all our Government vaccine depôts in India at present, so that there is not the least chance of any disease-germs being introduced with the vaccine. After a tube of vaccine lymph is opened it should be used at once or thrown away.

The ordinary way of vaccinating is as follows:—The arm is cleansed by washing it with warm water and soap, and if it is thought necessary with some rectified spirit. The arm is dried. The ends of the capillary glass tube containing the lymph are broken off, four small drops of lymph are blown on to the skin on the outer and upper part of the arm over the deltoid muscle one inch apart, or two on

corresponding parts of each arm, and through these drops superficial cross-scarifications or painless scratches are made with a lancet or surgical needle that has been previously sterilised by boiling or by holding it over the flame of a spirit lamp. It is not necessary to draw blood during this little operation. Finally the lymph is well rubbed into the scarified areas. Then the arm is allowed to dry, and a plain bit of aseptic gauze or lint is applied. As the vesicles rupture at the end of a week, some boracic acid powder may be sprinkled on them or a pad of absorbent cotton-wool applied, and this should be changed occasionally until the scabs separate. If a total area of half a square inch is vaccinated in infancy, it protects for ten years, at the end of which time re-vaccination should be carried out (see p. 404).

TUBERCULOSIS.

*Tuberculosis** is an infectious disease due to the growth of the tubercle bacillus in the tissues and is characterised by the formation of nodules of tubercles which unite and form cheese-like masses that tend to break down. The disease may be local or general. Tuberculosis attacks many mammalia, besides man ; it specially attacks domestic cattle, a fact which has great and immediate bearing in many cases of human infection. The commonest local form is *pulmonary tuberculosis.* It also attacks the bones, the joints, lymphatic glands, especially those of the neck and abdomen, the membranes of the brain (producing *tubercular meningitis*, acute hydrocephalus or "water in the brain"), the intestines, the delicate covering outside the intestines (peritoneum), the skin (causing lupus, a form of cutaneous tuberculosis), the eye, the larynx and practically every organ and tissue of the body. The one cause of all these manifestations of tuberculosis is the presence of a microbe, the *bacillus tuberculosis.*

It is essentially an infectious disease. In connection with the lungs infection is slow, and the disease as a rule runs a long course, and in the vast majority of cases ends fatally. It may, however, be rapid, run a speedy course, and be quickly fatal.

Prevalence.—Tuberculosis is one of the deadliest diseases of mankind, killing about one-seventh of the human race. In the British Isles the disease is responsible for more deaths than any other three diseases. The havoc wrought by consumption in India is enormous. All our large hospitals have cases, it exists in every village and more so in towns, and in the Army in India it is one of the chief causes of death and invaliding. It is very common in the deltas of the large rivers, especially in Lower Bengal and Assam, along the whole sea border, in the Deccan, and along the Frontiers of India and Burma. It is specially common in all the valleys of the lower ranges of the Himalayas and in the Terai.

There are about 127 cases of tuberculosis of the lungs with an average of 16·5 deaths amongst our European troops annually. Tubercle

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* *Tuberculosis* is a universal malady occurring in all latitudes of the globe. It is included here because of its being one of the chief causes of sickness and mortality in the service in India.

of the lungs is much higher in the Native Army. During the years 1900—1904, the average number of our British soldiers in India who died from tubercular diseases was 28, whilst 212 were admitted into hospital, and 116 were invalided. In the Native Army in India during the year 1904 the numbers were—deaths 55, admitted 465.

It is satisfactory to note that during 1905 both the admission and death rates on account of the tubercle of the lungs among Native troops have shown an improvement on the exceptionallylow rate recorded in the previous year. The accompanying table shows the admission and death rate for this disease (1) among the Native Troops of India as a whole, and (2) among Gurkhas, for each year of the past decade. The admission rate of the Native Army during 1905 was the lowest recorded since 1897, and that of Gurkhas was the lowest recorded in the decade 1896—1905. The decrease in the death rate is still more marked. The rates for 1905 of both the Native Army as a whole and of Gurkhas were the lowest in the decade, the rate of the latter being exceptionally low.*

ADMISSIONS AND DEATH RATES FOR TUBERCLE OF THE LUNGS.

Years.	Native Army of India as a whole.		Gurkha Regiments.	
	A.	D.	A.	D.
1896	2·5	·65	7·4	3·59
1897	2·6	·79	10·3	5 55
1898	3·5	·63	13·1	4·45
1899	3·3	·68	15·4	5·09
1900	3·7	·78	14·4	4·34
1901	4·2	·84	13·1	3·95
1902	4·3	·80	15·6	4·24
1903	5·9	·68	28·9	2·88
1904	3·9	·51	10·6	2·66
1905	3·1	·50	6·1	1·58
1906	2·5	·52	5·2	2·41
1907	2·5	·33	4·8	1 03
1908	3·0	·42	5·0	1·43
1909	2·3	·39	4·0	1·3

The incidence of the disease in both European and Native troops is gradually decreasing. The following table gives the admissions, deaths and invalidings in European troops from 1900-1909:—

	Admissions.	Deaths.	Invalidings.
Mean of the years.			
1900-1904	212	28	116
1905	148	20	116
1906	114	12	92
1907	114	14	107
1908	93	16	73
1909	81	9	66

*Annual Reports of the Sanitary Commissioner with the Government of India, 1905 to 1909.

The total admissions for *tubercle of the lungs* amongst native troops in 1907 was 322 with 42 deaths; in 1908, 378 with 53 deaths, and in 1909, 308 with 51 deaths. In 1908 there were 77 cases with 22 deaths among Gurkha riflemen as compared with 62 cases and 14 deaths in 1907, or 5·1 and 1·43 per 1,000 as compared with 2·7 and 0·28 in the rest of the Indian Army; in 1909 there were 77 cases with 22 deaths. There has, however, been a steady decline of tuberculosis in Gurkha troops. The following table gives the admission rates per 1,000 of strength among Gurkha troops for the years 1899 to 1909:—

Years.	Admissions.	Deaths.
1899	15·4	5·09
1900	14·4	4·34
1901	13·1	3·95
1902	16·6	4·24
1903	28·9	2 88
1904	10·6	2·68
1905	6·1	1 58
1906	5·2	2·41
1907	4·8	1·03
1908	5·0	1·43
1909	4·0	1·3

Tuberculosis of the lungs is commonest between the ages of 15 and 30 years. Its onset is very insidious as a rule, so that it is often advanced before the patient is seen by the medical officer.

The predisposing causes of pulmonary tuberculosis are heredity, defective sanitary surroundings, especially bad ventilation, deficient food, living on damp soils in low-lying valleys and deltas of rivers, undue exposure, occupations associated with the inhalation of dust and particulate trade refuse, knife-grinders, stone masons, cotton spinners; exhausting diseases, especially those in which catarrhal pneumonia occurs as a complication.

Of the *predisposing causes* one of the most important is *heredity*. In about 30 per cent. of persons with consumption, there is a family history of the disease. A predisposition to the disease is inherited; the children of tuberculous parents are less resistant to the tubercle bacillus. People with an hereditary history of consumption are less likely than others to be speedily cured. In a strict sense, however, tuberculosis is not hereditary, although we know that consumption does affect some families one generation after another. It is probable that the offspring of consumptive parents are not born with the disease, but that they are born with a condition of tissue which does not resist invasion by tubercle bacilli to the same extent that ordinary persons do. The fact of living with infected parents, apart from heredity, frequently leads to tubercular infection. Persons suffering from

chronic diseases that affect vitality and strength are liable to be attacked by consumption. It often follows upon chronic malarial infection, kala-azar, and diseases of the lungs.

Exposure and *dusty atmosphere* has an irritating effect on the lungs and predisposes them to the successful attack of the tubercle bacillus, and this dust has often the bacillus in it. Dusty and dirty work-rooms of all kinds, dusty houses, barracks, etc., all predispose to consumption.

Defective ventilation and overcrowding is a powerful predisposing cause. This cause is most potently at work in the overcrowded badly ventilated houses of the poorer classes in towns and villages. Unhealthy surroundings and bad hygienic conditions generally predispose; it is specially met with in low-lying, moist, damp soils, and damp houses.

Defective and deficient food is one of the most important predisposing cause of the disease in the poorer classes.

Alcoholic intemperance not only predisposes the individual to consumption, but also probably renders his offspring liable to infection by the disease.

In a large number of *post-mortem* examinations it is observed that there are indications of previous or recent consumption without its existence being known during life. We all inhale and swallow these bacilli from time to time and yet in the majority of persons it does no harm. The explanation for this is that in all probability the germ can do no damage unless some predisposing cause or causes render the body susceptible to the attack of the bacillus. Persons of poor physical development are more predisposed to it than those well developed, although powerful men may be attacked. It often affects persons with flat narrow chests.

The phlegm of consumption is the infectious agent; it contains millions of virulent tubercle bacilli. A single case of consumption in a barrack-room may be sufficient to sow the seeds of the disease in many persons, especially if there is already a susceptibility to this infection. To infect the lungs the microbe must be introduced in sufficient numbers and be of sufficient virulence.

The essential lesion produced by the growth of the bacillus is a *tubercle*, which is a small greyish semi-transparent nodule, embedded in the tissues around. By the union of several adjacent nodules tubercular masses are formed (tubercular infiltration). The tendency is for these masses to change into a sort of cheesy material. This is due to the absence of blood vessels in the nodules, and the action of the peculiar toxins or poisons formed by the bacillus. These cheesy masses break down, and in the case of the lungs form cavities which extend by the breaking down of further tubercles in the limiting walls of the cavities.

As previously stated the essential cause of tuberculosis is a microbe (*bacillus tuberculosis*, Koch) which gains access to the lungs from the air by inhalation. This bacillus is discharged in enormous numbers in the expectoration of persons suffering from the disease. The germ is a very hardy one and can withstand drying and continue a latent vitality outside the body. Hence it is found in the air of the rooms these sufferers inhabit, it has been found in the air of streets, and been cultivated from the dust of pavements. In some countries of Europe people are now prohibited from spitting in public places; patients with pulmonary tuberculosis are obliged to make the fact known to the local authority, and they are compelled also to discharge their expectoration into a vessel containing some disinfectant, which vessel they carry about with them. The expectoration of all tubercular cases should be incinerated.

The tubercle bacillus.—The tubercle bacillus is a small, motionless, rod-shaped body which is often very slightly curved. It stains slowly with the aid of heat and it is difficult to extract the stain from it by means of acids. This fact is made use

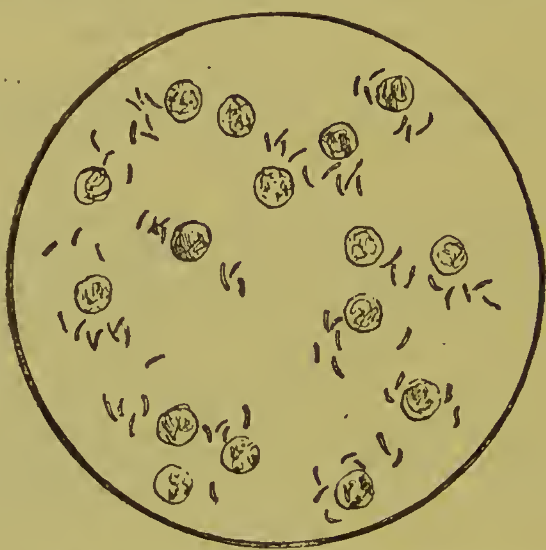

FIG. 83.—Tubercle bacilli from the sputum.

of in staining to differentiate it from other organism like it. The tubercle bacillus is often beaded. There is nothing distinctive in the early signs of tuberculosis of the lungs except the presence of the bacillus in the phlegm.

We will here deal only with tuberculosis of the lungs which is by far the commonest form met with in the Army in this country.

Tuberculosis of the lungs.—Tuberculosis of the lungs, commonly called *consumption* and *phthisis*, is a morbid state of the lung tissues due to its invasion by the tubercle bacillus, and characterised by the formation of tubercles which subsequently break down and give rise to destruction of the lungs and the formation of cavities in these organs. It is characterised by the occurrence of persistent cough, presence of streaks of blood in the phlegm, sweating at night, loss of appetite, loss of weight, and fever in the afternoons or evenings.

Symptoms.—Tuberculosis of the lungs or pulmonary consumption is first known by the patient gradually or rapidly losing weight, suffering from cough, breathlessness and night sweats. It is, for convenience, described as having three stages, although these run into one other. In the lungs there are many small grey spots which increase in number, and blend. These little masses or nodules of tubercle are very irritating to the lungs, and nature attempts to throw them off through the phlegm that is discharged. Each of the little specks mentioned contains the tubercle bacillus which started the process. When cavities have formed there is constant cough and usually a large amount of phlegm is brought up.

The walls of the holes or cavities are, in reality, large ulcers in the lungs, which go on increasing in size and eating away further portions of the lungs, the cavities thus enlarging and often opening into one another, and in breaking down a blood vessel is sometimes ruptured, and then there is more or less blood coughed up. This may be in such quantities as to at once threaten the life of the patient, or fill the lungs with blood and so suffocate. More frequently the blood is discharged in small quantities at intervals.

We diagnose this form of tuberculosis by finding certain changes in the chest walls and in the sounds heard on using a stethoscope. In the earlier stages these sounds may not be very definite, and then we examine the phlegm after staining it in a definite way under the microscope; if tuberculosis of the lungs is present we may find the characteristic thin red beaded bacilli. The finding of these bacilli makes the diagnosis positive. In the vast majority of cases of tuberculosis of the lungs there are other disease-organisms aiding and abetting the effects of the tubercle bacillus itself in its destructive action on the invaded tissues, and on the whole system by the toxins they create; the chief amongst these are the pus-producing organisms (streptococci and staphylococci) and the two varieties of the pneumonia germ. There may accidentally be others such as the influenza germ and the various microbes that give rise to catarrh of the lungs. These all fraternise with the tubercle bacillus. The addition of these various microbes in tuberculosis of the lungs seriously aggravates the disease. It has been stated that when the tubercle bacillus is the only micro-organism to contend against, that in the cases in the first stage under the best conditions of treatment from 75 to 80 per cent. may recover, but in association with abundance of pus-producing organisms the same percentage of cases will terminate fatally. Between these two groups of cases there is every shade of intensity of the disease.

Prevention.—A plan for the public prevention of pulmonary tuberculosis in India would embrace—the registration of all cases of the disease in man and of tuberculosis in animals; definite practical instruction in individual prevention to every case needing such instruction; the sterilisation of every house and its contents that has been infected by tuberculous patients; the establishment and maintenance of hospitals and sanitaria for the tubercular poor; the exclusion of tubercular subjects from occupations in which they can contaminate food, clothing, implements, and houses; pensioning of tubercular subjects deprived of occupation and of those dependent on them for support; extermination of tuberculosis among dairy cattle and domestic animals generally; inspection and regulation of dairies and all places supplying milk and of all slaughter-houses; restriction and regulation of the general habit of spitting in this country. It is hopeless to expect anything approaching the complete carrying out of such a scheme, but there are various suggestions in it which might be carried out, especially in towns. The more important of these are registration of the infected, disinfection of infected houses, isolation of the tubercular poor in hospitals, prevention of spitting except in authorised places, inspection of milch

cattle and their surroundings and of slaughter-houses, and exclusion of tuberculous subjects from occupations through which the disease is likely to be disseminated to the healthy. The carrying out of each of these suggestions is beset with difficulties in this country.

Isolation and invaliding.—In the interest of efficiency in the Indian Army it is imperatively necessary to eliminate every case of tubercle of the lungs from the ranks as soon as a positive diagnosis of the disease has been made. We are left no choice in this matter—for practical purposes the prospects of an ultimate cure in an odd case or two after prolonged treatment in regimental or station hospitals are so remote that they may be neglected. It is fully established by scientific medical opinion that pulmonary tuberculosis is a communicable disease. The expectoration of consumptives is the infective agency by which the disease is disseminated; it contains myriads of virulent tubercle bacilli. This microbe is a very hardy one, it can withstand drying and continue in a state of latent vitality outside the body for some time. Hence it is found in the air of rooms that are occupied by tubercular men and the floors and walls of such rooms may remain infective for some time after tubercular persons no longer occupy them; if special precautions are not taken with regard to their thorough disinfection, a single case of pulmonary tuberculosis may be sufficient to sow the seeds of disease in many persons, specially in those in whom there is a susceptibility to this infection. The dusty air that occurs in barrack-rooms with *leeped floors*, that is, floors covered with a layer of material consisting of clay and cow-dung, is, I believe, a condition that in former times intensified the predisposition to the disease by maintaining a congested state of the respiratory mucous membrane. This practice in many Native regiments still continues and should be condemned; the provision of impermeable floors for all barracks would remove the necessity for such leeping.

During the last ten years one has met with 13 cases of Gurkhas who remained at duty in the ranks until the disease was in the third or last stage (that of excavation of the lungs). In all these cases the men had certainly been infecting the barracks systematically for periods which probably extended to months. During the last 15 months two such cases have happened in the 2-8th G. R., one of these two illustrates the difficulties connected with disinfection for tuberculosis and the foci that may become infected through a single case. The man had been an officer's orderly, he had worked in the regimental soda water factory, and in the Gurkha Officers' Club, and lived in his company barrack-room. All these places had been infected and had to be disinfected. This happened notwithstanding that orders are periodically issued that all men with the slightest tendency to cough and fever are to report sick at once. As we have had only two cases in the battalion during the last 20 months, it may be interesting to state here the preventive measures against pulmonary tuberculosis adopted in the

2-8th G. R. The verandahs of every barrack are provided with iron dishes (*tawas*) containing a disinfectant solution (saponified cresol 1 part, water 160 parts) which are used as spittoons; spitting outside the spittoons is strictly prohibited. The doors and windows of all barrack rooms are kept continually open except in the most inclement weather when only those on the windward or rainy side are closed. When weather permits, the kit and bedding of all men are put in the sun twice a week for a couple of hours. During the last year, the barrack rooms have been provided with impermeable cement floors and ridge ventilation adopted. In most other Gurkha regiments similar measures are, I believe, carried out.

Tuberculosis of the lungs has undergone considerable decrease in late years amongst Gurkha troops, and this, I believe, is attributable to three main causes: greater attention to the ventilation of barrack rooms, prevention of spitting in barrack rooms, and the early elimination of cases from the ranks as soon as positive manifestations of the disease are present. All British officers, Native officers and section commanders, and corresponding ranks in the European Army, should be continually on the watch for tuberculosis of the lungs amongst the men, and every effort made to eliminate from barrack rooms all cases at the earliest stage of their occurrence. Section commanders should be held responsible that such cases are sent to the hospital at once. He would be a very unobservant section commander who did not recognise that a man of his section who had previously been quite well was suffering from a more or less continuous cough, fever, gradual or rapid loss of flesh and stamina, with breathlessness and sweating on slight exertion. There are exceptional cases in which none of these signs are manifest, but it is doubtful if such cases take any active part in the dissemination of the disease; infectivity commences when those with the disease commence to expectorate phlegm containing tubercle bacilli. There should never be any difficulty in spotting a man who has a constant cough and is spitting a lot.

Our routine practice in regimental hospitals (and that in practically all army hospitals in Europe) of isolating the cases and destroying the expectoration by heat or thorough disinfection, is based on the indisputable fact that the disease is communicated directly from man to man through tubercle bacilli contained in the expectoration.

It seems certain that, once the disease gets a foothold in barrack-rooms, there is always the danger of its spreading and the dissemination may take place rapidly. A barrack room that has been occupied by a case of pulmonary tuberculosis should be vacated, thoroughly disinfected, its walls scraped and white-washed, thoroughly ventilated, and all furniture, bedding and kit exposed to the sun. The nature, causes and measures for the prevention of tuberculosis should be taught by medical officers in their lectures on military hygiene every year. The

medical officer should keep a register of all weakly looking men and of those who are running down or losing weight for no assignable cause, and such men should attend hospital once a week for the medical officer's inspection. He may consider it desirable in some of these cases to apply Calmette's reaction, that is, the inoculation of a form of tuberculin into the conjunctiva of the eye which is followed by certain specific changes in those who are suffering from tuberculosis, but has practically no effect on healthy persons. This is a fairly accurate test, and when positive it shows the existence of a focus of tuberculosis in process of evolution or incompletely cured—one which contains some living tubercle bacilli. It may fail where the lesions are very virulent or extensive, but these are self-evident cases. Tuberculin for this purpose is procurable from all the larger chemists.

I have personally no doubt that a certain small proportion of men suffer from tuberculosis of the lungs in the ranks and completely recover without ever knowing that they have had it. The same happens in civil life. One has repeatedly performed *post-mortem* examinations on the bodies of persons dead of other diseases whose lungs showed traces of healed pulmonary tuberculosis. These men in barracks may be looked upon as "carriers" of the disease, and they are a danger to their comrades, by reason of no preventive measures being adopted. The closest scrutiny of men is at all times necessary to discover and eliminate such causes.

Frequently the disease is consecutive to malarial infection or to an attack of some other form of fever, such as typhoid, or to general debility arising from any cause.

Avoidance of exposure to infection—the sputum of tubercle cases. One of the commonest ways tubercle bacilli are disseminated is by people suffering from consumption spitting in barrack-rooms, in verandahs and in roads and streets. The germs then dry, pulverise, and are blown about. Persons suffering from tuberculosis of the lungs should never spit in barrack-rooms or barrack verandahs or in compounds, in public conveyances, nor into any vessels unless it contains a disinfectant; when indoors they should always keep a cup, bottle or hand spittoon containing a disinfectant. The spit should be incinerated. It should never be thrown on the ground outside; the spittoon should be emptied, thoroughly washed with boiling water, and then another lot of the disinfectant poured into it. The handkerchief used should be frequently changed and thoroughly boiled in boiling water before being sent to the *dhobie*. The expectoration should never be swallowed. The room occupied should be thoroughly aired and cleaned every day.

Whilst the prevention of consumption has chiefly to do with the extermination or circumvention of the bacillus, the most hopeful ways are those which aim at educating all ranks as to the nature of the

disease and how it is spread, and showing them how improved hygienic living and better sanitation may lessen it. Tuberculosis is to a large extent a preventable disease which only ignorance and neglect make possible in the present state of scientific knowledge.

All cases of severe cough, whether with or without fever, should invariably report sick. Such cough may be due to tubercle of the lung, pneumonia, pleurisy, or more frequently bronchitis ; for all of these conditions the hospital is the proper place, and attempts to throw off such disease may lead to permanent unfitness, apart from the fact that certainly with pneumonia and tubercle of the lung, the disease may be communicated to others inhabiting the same barrack room, tent or hut.

Occasionally on field service, from its hardships, privations, and exposure, men manifest for the first time the symptoms and signs of *tuberculosis of the lung.* Whenever such cases appear, even in the absence of the microscopical demonstration of the bacillus, and the medical officer is in doubt as to its nature, it is always safer to send them to the base, as such men are a source of danger to their comrades by reason of their exhaling and expectorating the germs of the disease.

Sun-Fever.

Synonyms.—Thermic Fever.

This is a non-infectious fever, arising from inordinate exposure to the sun mostly attacking Europeans. It may be slight or severe. In the slighter cases no notice is taken of it, and it often disappears in the cool of the evening ; in more severe cases it continues all the next day or for several days with malaise, loss of appetite, feeling of feverishness and possibly slight delirium. It occurs usually in April, May, and June, when the sun is hottest.

Symptoms.—It comes on suddenly with a feeling of chilliness, this is followed by burning heat of the skin, great thirst, full strong pulse, intense headache, flushed face, restlessness, nausea, vomiting and throbbing in the head. It usually lasts three days, the patient then recovering rapidly. It may, however, go on to cause hyperpyrexia.

This condition, though not in the *Nomenclature of Diseases*, 1906, is introduced here because one is quite confident that it is a cause of a certain number of cases of "fever" that occur in the hot weather among both European and Native troops. It was a generally recognised form of fever in this country 30 years ago, and accounts of it are included in all the older and classical works on the diseases of India.

It is brought about by the same conditions as real sunstroke, and is prevented by adopting the same measures as are laid down for that disease.

Heat Apoplexy.

Synonyms :—Sunstroke—Heat-stroke—Diathermasia.

This is an acute condition arising from a sudden disturbance of the heat regulating centres of the nervous system by exposure to high

atmospheric temperature, particularly when in combination with marked humidity, occurring in persons specially predisposed to the effects of the sun or in those unaccustomed to it, and characterised by fever with very high temperature, and usually with convulsions, coma, and congestion of internal organs, especially of the lungs and brain.

The human economy is capable of withstanding comparatively high atmospheric temperatures for a short time, but this adaptation often fails when the air is fairly well saturated with moisture. In this latter case the heat regulating apparatus of the body is disturbed and loss of heat by evaporation is prevented by the large amount of moisture already in the air; as a result the temperature of the body rises.

We have considerable power of adapting ourselves to, and keeping in good health under, the most diverse conditions of climate and temperature. Persons in health and vigour, leading temperate and hygienic lives, can endure much higher tropical temperatures than those who are less fit, and as we know, Natives can stand a higher temperature ordinarily than Europeans, yet even the former may find the sun heat beyond their powers of endurance under certain exceptional circumstances. In true sunstroke the high atmospheric temperature produces excessive activity of the heat-producing mechanism by paralysing those parts of the heat regulating centres which control the heat discharge (vaso-motor nerves and sweat glands).

The terms heat-stroke, sunstroke, heat apoplexy, insolation, and heat syncope, have hitherto included two very different conditions—(1) a state of exhaustion leading to syncope, and (2) an overheating of the nervous centres, blood and tissues, with a tendency to produce vaso-motor paralysis, excessive rise of temperature (hyperpyrexia) and subsequent asphyxia, through the action of heat on the respiratory centres. In association with this latter condition, certain lesions may occur, such as change in the tissues of the brain, hæmorrhage and more or less inflammation of the membranes of the brain. The symptoms in such cases are varied, and depend on the parts of the nerve centres affected. For the present we will confine ourselves to the second of these.

Sunstroke cases occur in most campaigns in the tropics.—In practically all our Frontier campaigns we lose a certain number of European troops, and sometimes men of our Native Army also, from heat-stroke, either on the march going to or returning from the seat of war, or during actual fighting. Hence it is necessary to be always prepared to deal with such cases. Sunstroke in hot climates is always a serious possibility with European troops, and even in our temperate home climate heat syncope (p. 538) occurs during manœuvres.

French in Madagascar in 1895.—An example of the effects of marching during the hottest part of the day was well illustrated in the French Army in Madagascar in 1895, in which the 14th Battalion of the 200th Regiment lost 40 per cent. from heat-stroke. One day in

May 1886 in Burma, of 125 men of the Munster Fusiliers during a mid-day march after a band of dacoits along the river Moo, 22 dropped down, 20 of them from heat syncope, two from real heat apoplexy.

Austrians in Bosnia, 1878.—In 1878 the Austrian troops occupying Bosnia had 2,131 cases during the campaign, one regiment alone having 320 cases. During the march to the relief of the Pekin Legation in 1898, it is stated that at one time one-fourth of the United States Command was unfitted for marching owing to the effects of the heat. In the Hazara Campaign of 1868, the 38th Regiment left Sialkote in August, to march to the rendezvous in the Black Mountains, and had 51 admissions for sun-stroke. In the Chitral Relief Expedition of 1895 a large number of our Native troops suffered considerably from the heat, especially as in the absence of cooly transport, the men were obliged to carry part of the baggage. We have previously referred to the losses of the 35th Sikhs between Nowshera and Malakand in their march to the relief of Malakand in 1897.

Direct exposure to the sun, whilst the most common cause, is not necessarily the only cause. One has attended two European women with heat apoplexy during the hot weather who never left their bungalows between 8 A.M. and 5 P.M. The condition is not met with above 6,000 feet in this country. Whilst a high air temperature with excessive humidity usually produce their effects during the day, they may also do so at night.

There are no disease-germs of any description to be found in any part of the body in sunstroke. The effects of the excessive body heat are especially marked on the cells of the cerebro spinal nervous system, and especially on those of the medulla oblongata. Every year we lose a certain number of European troops, and sometimes men of our Native Army also, from heat apoplexy. There were 26 deaths from heat apoplexy amongst European troops in 1907, 37 in 1908, and 15 in 1909.

The statistics given by different authorities as regards the mortality vary, but one's personal experience is that even when promptly and properly treated, the mortality from true sunstroke is over 60 per cent., and that all patients who become bluish or purplish in the face from congestion of the lungs and convulsions die.

True sunstroke is fostered by fatigue, tight-fitting clothes or compression about the chest and neck, thirst, debilitating diseases, constipation of the bowels, want of a proper amount of sleep, excesses of all kinds, especially alcohol, and constipation of the bowels. Europeans recently arrived in the country are more liable to it. Certain persons are especially susceptible for some unknown reason. Previous illness greatly predisposes to sunstroke. Stations in which hot winds are prevalent have invariably a certain number of cases of sunstroke each year. The most dominating predisposing cause is alcoholism; even when only moderately indulged in, it enhances the tendency to sunstroke. In chronic alcoholics heat apoplexy is very dangerous, as it is also in men worn out by fatigue and long marches.

Symptoms.—In real heat apoplexy, there is usually some warning indication of its approach, such as severe headache, fulness of the head, nausea, thirst, giddiness, mental confusion, feeling of weakness, lassitude, throbbing temples, and flushed face, which becomes purplish; the eyes are red, vision confused, there is frequent desire to make water, followed by high temperature, dry and pungently hot skin, the pupils are usually contracted, the condition passing rapidly into stupor, delirium, convulsions and coma, with stertorous and difficult breathing. The pulse is small, intermittent, and of low tension; convulsions in many cases come on early and last until near the end. The temperature rises rapidly to from 105° or 106° to 112° F. or higher. When the temperature passes beyond 107° F., in heat apoplexy, it begins to exercise a marked influence on the nervous system. Death occurs in from 2 to 48 hours. When heat apoplexy is present the heat regulating centres of the nervous system (the thermotaxic mechanism) are thrown out of gear, the temperature runs to a great height, and death often takes place from the direct action of the heat on the nervous system. In some cases death occurs within half an hour, some last a few days, and others recover after a time and are usually victims of severe headache or other nervous symptoms on exposure to the sun. The patient sometimes partially recovers and then a relapse sets in. The condition is always very dangerous; death occurs in over 60 per cent. of the cases. Heat apoplexy may set in suddenly with very acute symptoms and death may occur in a very short time. There is practically no condition that simulates real sunstroke. Hyperpyrexial pernicious malarial attacks (p. 462) may, in the absence of a medical man (who would diagnose the case by examination of the blood and finding malarial parasites in it), be very difficult to diagnose.

The hyperpyrexia of acute rheumatism is preceded by the characteristic symptoms and signs of the disease. Cerebro-spinal fever (p. 508) is recognised by the facts that it is usually epidemic, the temperature does not run so high, there is rigidity of the neck, and the head tends to bend backward.

Treatment.—As soon as any of the premonitory signs appear precautions should be adopted and preparation made to treat hyperpyrexia should it come on. If in a barrack-room he should be moved to a verandah or the open air (out of the direct rays of the sun), loosen everything constricting the neck and chest, remove the clothes, put him on a sheet, raise the head slightly and turn it to one side. Now saturate the sheet with cold water, preferably iced water, and keep pouring it over the patient continuously from the head to the feet. This can readily be done by means of a long rubber tube connected with a water tap where there is a public water-supply, or by a *bhistee* who should stand on a stool and pour the water over the patient from a *mussakh*, another *bhistee* being ready to relieve him when the *mussakh* is empty. The stream of the water should be about half an inch in diameter and not too forcible. If available ice should be applied to the head. Nothing should be given by the mouth until the patient is conscious.

On the march when sunstroke has occurred the equipment should be removed, the clothes loosened, and the man carried to any shade available His head, neck, and face should be bathed with cold water and he should be vigorously fanned. If he can swallow he should be given small quantities of water at short intervals, and he should be allowed to rest quietly until the arrival of the medical officer and ambulance transport.

After recovery heat-apoplexy may be followed by irritability of temper, headache, etc., especially on re-exposure to the sun.

The main effect of the condition is the production of deep congestion of internal organs, especially of the brain (the vessels of which both outside and inside are engorged with blood) and the lungs.

Prevention of heat apoplexy.—When possible work in the hot weather should be done in the morning and evening. The helmet should always be worn from sunrise to sunset. It is said to be advisable to have this, or any other headgear used, lined with red or orange coloured flannel. These precautions are specially necessary in the unacclimatised. All unnecessary exposure to the direct rays of the sun should be avoided; as should also all lying about or sitting in the sun. In houses and barrack-rooms, free ventilation should be arranged for, punkahs or electric fans keep the air circulating, and help evaporation from the surface of the body. If there are any signs of being affected by the heat of the sun, or the atmospheric temperature, it is a useful precaution to douche the whole head and back of the neck with cold water.

Rate of marching in sun.—It is well known that in hot weather the more rapid troops march beyond, say 3 miles an hour, the greater the number of cases of heat-stroke occur; similarly, the ratio of cases increases with the length of the march, and this apart from the question of the actual number of hours men are exposed to the sun's influence. In actual fighting the mental strain and unconscious muscular rigidity which accompany military movements favour the occurrence of sunstroke.

Best time to march.—The troops should not be marched during the day, the best time is during the early hours of the morning. It is rare that it will be necessary to march during the middle of the night.

Clothing.—The clothing worn should be suitable to hot weather, and our present khaki coats worn over a flannel shirt, with "shorts", can scarcely be improved upon.

Head and spine covering.—In our European officers and troops the head, temples, and back of the neck and spine must be well protected, and a special non-conductor in the shape of a detachable spine and back pad of quilted cotton wool is of great service in protecting a vulnerable

part of the nervous system from the sun, especially when the latter beats on the back. Many experienced sportsmen use this when shooting in the hot weather in India. A handkerchief between the helmet and the head is also some protection, and green leaves of any kind, if available, still better.

Coats should be opened.—The men should be directed to completely open their coats.

Morning meal before marching.—Before marching in the early morning, the men should have a light breakfast—they should never be allowed to start on an empty stomach. This meal is not to be a heavy one, but it should be sustaining.

Effects of actinic rays of sun.—It has been suggested that the actinic rays may be an important factor in the production of heat-stroke and that these should be arrested by a layer of coloured material acting as a filter; yellow or green is such a colour; under-garments and a hat-lining of one of these colours have been used. It has also been suggested that there may be solar rays other than ordinary heat rays which may be arrested by metals. To effect this it has been proposed to let in a thin layer of tin foil or other metal into the substance of the tents and of hats.

Reflected rays of sun.—It is stated by some authorities that some of the symptoms of sunstroke are caused by the reflected rays of the sun through the eyes, the optic nerves being exposed to the direct rays of sunlight. Without discussing the validity of this assertion, we know from experience that neutral-tinted glasses decidedly afford much relief and comfort to the wearers in a bright hot sun. Such glasses in the form of goggles were effective in our Egyptian campaign in 1882 as a protection against glare, heat, sand and flies.

Perspiration not to be checked.—Anything which interferes with loss of body heat predisposes to sunstroke, such as too heavy clothing, diminished perspiration from deficient water-supply, or lessening of evaporation from the surface from excessive humidity of the air. One has seen as many as five European sailors under treatment in the European General Hospital in Calcutta, on the same day in the month of May, when the shade temperature was well under 100° F., but the humidity of the air between 70 and 80 degrees of saturation (p. 13).

March in open order.—Men should march in as open order as possible to allow free access of fresh air to each soldier. Halts should be frequent and whenever possible in shaded elevated places. During the halts the men should not lie down on the bare ground except under the shade of trees, as the ground is often hotter than the air and the men's bodies.

Unnecessary fatigues to be stopped.—All violent exercises are to be avoided. All unnecessary fatigues, piquets, and other trying duties, should be avoided as much as possible; this applies especially to the middle of the day. All drills should be reduced to a minimum.

Company officers to watch their men on the march.—When marching in unusual heat, company officers should watch their men carefully. When a soldier looks pale, weak and exhausted, he should be told to fall out and rest, aud be brought in by the ambulance transport.

Water bottles to be filled.—The water-bottles should be filled at the halts. Water should be drunk in small quantities at a time, and may then be used frequently. Arrangements for having water carried should be ensured before the march. This is most important. There must always be an organised system for the conveyance of sterilised water on the march, and of having it in the field during an action. Water should always be easily accessible to the men throughout each day's march, and in camps, at all times.

Best form of beverage.—For a hard day's work in a hot sun probably one of the best beverages is cold tea without milk or sugar.

Alchohol to be strictly interdicted.—The issue of a spirit ration in the fore part of the day under any circumstances should be interdicted; the old notion that ardent spirits of any kind was a prophylactic against malarial infection, cholera, chills and disease generally, has been exploded. The use of alcohol in any form previous to beginning or during a march, is to be absolutely prohibited. "Alcoholic drinks, gluttony, excess of animal food, too much tobacco smoking, in fact dissipation of all sorts, are specially to be deprecated."*

Camps should when practicable be pitched in airy places, preferably on grass and under spreading trees, and on areas free from undergrowth. Double canvas and grass or boughs laid on the tents will lessen the temperature within. In this connection in standing camps, a thatch erected over the tents adds much to the men's comfort, and this is usually practicable.

Daily supply of ice for force if obtainable.—When cases of heat-stroke are expected, if ice is procurable in the district or province, arrangements should be made for an adequate supply of it to reach the force daily.

HEAT SYNCOPE.

Synonyms:—Heat Exhaustion, Phœbism.

In sun syncope or heat exhaustion the patient becomes pale and giddy, and falls to the ground; there is partial unconsciousness; the condition is one of syncope or faint, the pulse is weak and small,

* Sir PATRICK MANSON, *Tropical Diseases*, 4th edition, p. 295.

the breathing, which may be stertorous, is usually shallow, the pupils are dilated, and the skin is cold and covered with a clammy sweat. The patient usually recovers rapidly, but occasionally the shock is so severe as to lead to rapid heart failure and death. There is often a severe headache following this condition, and in some cases an irregular fever. Occasionally inflammation of the membranes of the brain, or other form of brain trouble may follow it.

Heat exhaustion is specially liable to occur when excessive humidity is associated with high atmospheric temperature, but this latter factor is not essential, as it often happens in Northern India, when the air is particularly dry.

Heat syncope often picks out those who are in a poor state of health or have recently been ill, especially when the illness gave rise to any form of degenerative change in the heart muscles which permits of the heart undergoing rapid dilatation under the strain of a high atmospheric temperature. This in all probability is the explanation of the manner in which chronic alcoholism operates in predisposing to heat syncope, as in such cases there is almost invariably some degree of fatty degeneration of the heart.

When the actinic rays of the sun act on a susceptible person, it produces a condition, resembling either aggravated fainting or syncope or a form of shock. It is common amongst troops marching in the sun or people working in the sun, especially when in association with scanty food and hardship generally. It is considered to be a form of cerebral shock caused by exposure of the head and spine to the ultra violet rays of the sun's spectrum. It is associated with an acute congestion of the brain and spinal cord which is usually only very temporary, but may in some cases be followed by chronic inflammation of the membranes covering these organs. It is specially liable to affect young Europeans coming to this country. The condition is one to which acclimatisation is possible. Natives are, however, liable to it and one has treated 11 men in one Native Infantry regiment of 700 strength for it on the march in the North-Western Frontier in September, and 9 men in another Native Infantry detachment of 175 on the march in Upper Burma in May. The slighter forms of it are constantly met with in Native troops during manœuvres and on the march.

Another minor effect of the actinic rays of a hot sun after prolonged exposure is severe sunburn, often with the formation of blisters, severe headache and fever. This condition is rapidly recovered from and is due to the action of the special rays named.

Treatment.—In mild cases move the patient to the shade, open the clothes, place him in a recumbent posture, splash cold water on the face and neck, and apply smelling salts to the nostrils. If he can swallow give him a drachm of sal volatile in a wineglassful of water. In severe cases apply a mustard plaster to the chest and nape of the neck, and if the temperature threatens to run up, wrap the patient in cold wet sheets and give cold water to drink.

Prevention.—The preventive measures are practically the same as for heat apoplexy.

ASIATIC CHOLERA.

This is an acute specific infectious and highly malignant disease, which occurs endemically in various parts of India throughout the year, whence it spreads and occurs in an epidemic form at certain seasons. It is characterised by severe vomiting, violent purging of watery motions which look like rice-water, severe cramps in the abdomen and legs, great depression and coldness of the surface of the body, suppression of urine and intense collapse. The cause of the disease is the *comma bacillus* of Koch. which usually gains access to the system by means of specifically contaminated drinking water. The home of cholera in India is the Delta of the Ganges, although it occurs endemically also in towns on the bed of other rivers. There are certain districts in India in which cholera is practically never absent. In such places the only factor necessary to light up epidemics of the disease in cantonments is neglected sanitation, especially neglect in regard to the water-supply, milk-supply and food-supply generally.

The comma bacillus when it gains access to the bowels in any numbers rapidly multiplies and produces a toxin or poison which is speedily absorbed by the blood, and causes the symptoms of the disease—vomiting, purging and collapse, and it may be death in a few hours. The comma bacillus may grow in the soil under certain conditions. It multiplies in dirty water. It is often carried beyond the endemic areas by infected persons and infected articles, and if the conditions are favourable for the microbe in this new place, it soon become epidemic. The most common cause of cholera is the use of drinking water contaminated with cholera bacilli. Another common cause is the dissemination of cholera germs from clothing and bedding infected by the discharge from cholera cases. Flies are in some way connected with the spread of cholera, probably by infecting food through comma bacilli carried from an adjacent infected focus on their feet, wings and fleshy proboscides. There is a certain amount of evidence pointing to the probability that cholera may be dust-borne. It may also be communicated from person to person by contaminated food, drink, and feeding utensils. Cholera travels along roads and railways. Once cholera is started it will with neglected sanitation travel along with troops from camp to camp. Natives suffering from mild or latent cholera performing their ablutions after defæcation in and near tanks, wells, streams and reservoirs, occasionally start epidemics of the disease. One has seen this occur on several occasions.

The cholera bacillus.—The bacillus of cholera is curved like a comma; it is actively mobile, having, as seen in this country, only one flagellum, which is at one end. In its growth it liquefies gelatine in 50 hours. Complete drying kills the germ in a few minutes. It is also soon killed by dilute acids. The bacillus

multiplies in the lumen of the small intestines, and in the glands, epithelial cells and mucous membrane of this part of the alimentary tract. The bacillus produces an endotoxin whichis set free and gives rise to the symptoms.

Fig. 84.—Comma bacillus of cholera. Magnified 1,000 times (after Hewlett).

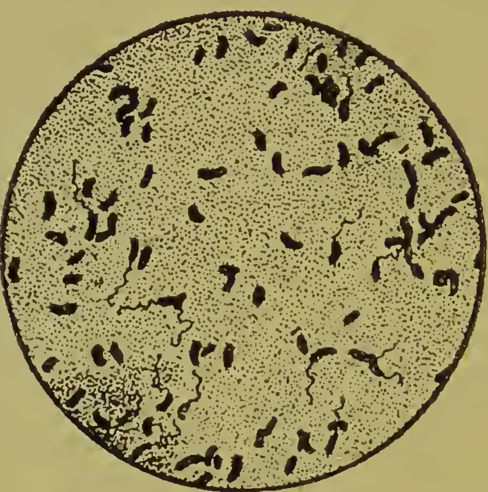

Fig. 85.—Comma bacillus of cholera showing flagella (after Mallory and Wright).

The comma bacillus has comparatively little resistance ; it is killed by weak disinfectants, and also by exposure to the rays of the sun for a few hours. It is capable of living in water for a few days at least, and in dirty water, such as that of tanks and shallow wells, it multiplies and lives longer. It is disseminated by means of articles of clothing and bedding that have been soiled by discharges from cholera patients. The unwashed hands of persons who have suffered from the disease, or of those who have been attending cholera cases may contaminate food.

For statistics as to the prevalence of cholera in past years see Part I, p. 24. In European troops in 1908 there were 93 admissions with 76 deaths and in 1909 only 12 admissions with 7 deaths. Amongst native troops in 1905 there were 174 admission with 116 deaths, and in 1909 only 26 admissions with 18 deaths.

The *incubation period* of cholera is usually from two to five days.

Symptoms.—Cholera may begin suddenly or be preceded by premonitory symptoms, especially diarrhœa, for some days. It often begins during the night or early morning, particularly in Europeans, and if not properly attended to at once may rapidly prove fatal. There is a feeling of great depression and weakness, spasmodic griping pains in the abdomen, then purging and vomiting, the vomited matter consisting first of the contents of the stomach and then a watery fluid. The stools at first fæcal, soon become rice-water-like in character, and there may be 15 or 20 of them in a few hours. They are expelled with much force. The vomiting occurs without effort and often in large volumes. There are severe cramps in the calves of the legs, thighs, and in the abdomen. There is now a sinking feeling which becomes progressively more pronounced. The fingers become bluish and wrinkled. The urine is at first scanty and highly coloured, and then ceases to be formed, the bladder remaining empty. A burning sensation in the abdomen, especially at the pit of the stomach, is frequently one of the most distressing symptoms; it certainly was on both occasions when one personally had the disease. The tongue has a bluish colour, is cold, and feels like a piece of dead fish. The mouth is dry, there is great thirst especially for cold drinks. The pulse at first feeble, is gradually lost at the wrist; the skin is cold yet the patient feels hot and throws off any covering placed over him. He is very restless, and is constantly jerking his body, jumps from one side to the other, and there may be curious noises in the ears. The patient now passes into the stage of collapse. The skin is bluish-grey and covered with a cold clammy sweat, the body shrivelled, the voice is faint and husky, the breath cold; whilst the mind is clear there is great apathy; the eyes are sunken, the face parched, the cheeks hollow and the lower jaw falls. The pulse cannot be felt, the motions pass involuntarily, there may be hiccough and the patient may soon die, the temperature sometimes rising before the end occurs. This state of complete collapse may last some hours and then if the patient rallies the pulse returns. The other favourable symptoms are—cessation of the vomiting, purging, and cramps, return of warmth to the skin, and more strength in the voice, secretion of urine commencing, the appearance of bile in the stools, and cessation of the burning pain in the pit of the stomach. When recovery is to take place it is usually rapid.

Ambulatory cholera.—Some cases of cholera are very mild, the patient suffering only from a trifling amount of diarrhœa so that he is able to go about and does not take to his bed, or even seek treatment. These are most dangerous cases to the public, as they are scattering virulent cholera bacilli about the locality. All cases of diarrhœa during cholera periods should be rigidly isolated until definitely diagnosed by a medical officer not to be cholera. Mild cases, however, may, after several days' slight diarrhœa, be suddenly attacked by acute symptoms of cholera and die in a few hours.

The symptoms of cholera are those of an intense blood poisoning, and arise from the absorption of toxins manufactured in the bowel by the comma bacillus. The bacillus is only found in the alimentary tract. The rice-watery material seen in the motions is also found after death in the large and small intestines; the mucous membrane of the whole alimentary canal is red and very congested.

Duration.—The duration of the disease varies from a few hours to several days. Mild cases after suffering from vomiting and purging for a few hours get rapidly well without passing into the stage of collapse; the more severe cases always become collapsed from which recovery (if it takes place) occurs in from two to several days. At the beginning of severe epidemics many cases die in a few hours, collapsed with few if any of the characteristic symptoms of cholera, or after passing a few rice-watery evacuations—these are known as *fulminating cases*. The disease is always more fatal at the beginning of epidemics, and almost always less severe towards the end of epidemics, when it is supposed that the bacillus of the disease has lost some of its virulence.

Diagnosis.—Other conditions may simulate cholera. Amongst these are severe simple diarrhœa, the algide form of pernicious malarial attacks (p. 462) poisoning by

arsenic, eating poisoned tinned provisions (p. 198), especially fish, sausages, oysters (ptomaine poisoning), and using impure unboiled milk. The non-medical man cannot distinguish severe ordinary simple diarrhœa from the early stage of very mild cholera.

Severe diarrhœa may be associated with all the symptoms of cholera (vomiting, purging, cramps, low temperature, etc.), but there are never the characteristic rice-watery evacuations. Cholera is sometimes for days preceded by diarrhœa, whilst ordinary simple diarrhœa having no connection with cholera occurs during cholera periods. There is also no doubt that the common colon bacillus, a normal inhabitant of the bowels, may take on virulent properties and produce a severe diarrhœa which simulates cholera.

Prevention of Cholera.—The greatest general safeguard against epidemic cholera is a sound state of sanitation in cantonments—a good water-supply, good drainage, a good conservancy system, and good kitchen arrangements. When a cantonment is provided with a public water-supply, all wells should be permanently covered up, and certainly all wells with water of questionable quality should be permanently closed.

The chief way the germ of cholera gets into the bowel is by means of drinking water. If a water-supply once gets contaminated with cholera germs, it will certainly give rise to a number of cases of cholera in those using it (see p. 105). The excreta of cholera patients may be thrown into cesspits and thence reach any adjacent well. I have on three occasions traced epidemics of cholera to the contamination of wells from *sundasses* or privy-pits dug in the ground where these latter were adjacent to wells. On two of these occasions the cholera bacillus was actually cultivated from the well water. In the third case the epidemic rapidly ceased after closing the well. If the water-supply is from wells, all suspected wells should be permanganated (p. 118), and if no permanganate of potassium is available, quicklime (1 to 1,000 of the water, p. 118) should be used, stirring up the water afterwards for an hour.

The cleanliness of all latrines should be rigidly attended to. There should be increased sanitary vigilance throughout the cantonment, and this should begin if possible before the arrival of the disease. If obliged to be in camp, the camp should be to the windward side of the infected area; and no communication with the infected area should be allowed—neither the water-supply, milk, nor food should be got from the infected area, and no matter what its source, all water and milk should be boiled. In many severe epidemics it is usually necessary to vacate the infected barracks or tents. During cholera periods it is specially necessary to avoid chills, especially chills of the abdomen, and this is best done by the use of a cholera belt. Alcohol in excess should be avoided as it lessens resistance. It is specially necessary to avoid the use of fish, tinned provisions, unripe fruit, badly cooked vegetables, rice or atta, and badly made bread. Avoid also exposure to the mid-day sun, night dews, any great mental or physical fatigue,

and the *use of purgatives* and heavy meals. All water drunk should be at least boiled, and preferably boiled and filtered through a reliable filter (pp. 125-130). In cantonments cholera medicines should be kept at the quarter-guards or some central buildings. One of the most useful are the old cholera pill, which consists of 1½ grains of asafœtida, 1 grain of red pepper, and ½ a grain of powdered opium, one of which are to be taken after each stool *during the first stage only*. Another excellent remedy for the first stage is dilute sulphuric acid 15 drops, tincture of opium 15 drops in water every 2 or 3 hours. During cholera periods the slightest attack of diarrhœa should be rigidly treated and the person affected sent to hospital at once. The early diarrhœa may sometimes be checked by chlorodyne 20 drops and brandy an ounce.

Amongst the prophylactics which have from time to time been recommended are—quinine, five grains daily; dilute sulphuric acid lemonade (15 minims to the bottle), sulphurous acid lemonade (half a drachm to the bottle); oil of eucalyptus 10 minims twice a day.

Aerated waters are to some extent a safeguard from the disease, if they have been made for over four hours, and, if in the case of so-called "soda-water", bicarbonate of soda has not been used. The carbonic acid gas in well made soda-water certainly kills the germs of cholera within 24 hours.

All discharges from the bowels and stomach of a cholera patient are infectious. If these and his soiled linen are at once disinfected the disease is not dangerous to others. If the discharges are not disinfected the comma bacillus may gain access to food or water and then the disease spreads.

Precautions against cholera on field service.—Whenever a cholera-stricken country or district has to be marched through or invaded, the chief sanitary officer with the approval of the principal medical officer of the force, should draw up a series of rules detailing the precautionary measures to be adopted against the disease, and the steps to be taken in the event of the actual occurrence of any cases in any part of the force, and these rules should be made known to all ranks throughout the force. Such rules should refer to the facts that the essential cause of the disease is the comma bacillus which is contained in the discharge of cholera cases, that water contaminated by this spirillum is the usual cause of epidemic cholera, that the greatest possible attention is to be given to the water-supply, boiling being the greatest safeguard; the precautionary measures to be adopted will insist on the urgent necessity of having cases notified, brought under treatment, and isolated at the earliest possible moment; and the urgent necessity for the disinfection and incineration of all excreta.

Frontiers where epidemic cholera prevails to be avoided if possible.—Unless military reasons imperatively demand it a region infected with widespread cholera should not be invaded. Under such

circumstances it is practically beyond the power of human effort to prevent its appearance in the invading force. Fortunately there are not many instances of cholera epidemics in recent years during our Frontier wars. Nevertheless, in certain parts, and at particular seasons, we should be prepared for the possibility of such a disaster. In the 3rd Burmese War (1885—87) several regiments suffered. One's present regiment (then the 43rd Gurkhas), was decimated in going up the Irrawaddy in 1886. The same regiment was again assailed by this dire malady in marching from Kohima to Shillong in 1900, when the commanding officer died of it.

Whenever military operations are being conducted in an area where cholera already is prevalent, an epidemic of the disease may occur in the force. In the last Mohmund Expedition in 1908, which lasted only a short time, there were 50 deaths from cholera, one European regiment having 43 cases with 36 deaths in four days. The board of inquiry on this epidemic attributed it to the drinking of way side water on the march to Shabkadar.

Comma bacillus, the essential cause of cholera.—The one cause of cholera is the *comma bacillus* (KOCH), and epidemic cholera is caused only by this microbe in a virulent state getting into the alimentary tract, and it does so in epidemic cholera practically always through specifically contaminated water. In the bacteriological examination of water as regards the comma bacillus of cholera, the earliest results obtainable are in six hours, and for absolute and positive evidence, when germs like those of cholera are present, other isolation processes have to be undertaken to demonstrate satisfactorily that the cholera vibrio contaminates a water-supply. This shows the impracticability on field service in an enemy's country of thoroughly examining the water daily. It is fortunate for India that the cholera vibrio can live only a few days in our water-supply, and when the same water continues to give rise to the disease, it is certain that fresh accession of the cholera germ is taking place.

Disinfection and incineration of cholera discharges.—The infective poison of cholera is contained in the vomited and purged matters of patients suffering from it. These must therefore be thoroughly disinfected and incinerated at once. They should be discharged into a utensil containing a liquid disinfectant. It is a safe rule to burn the clothing and bedding of cholera cases.

Difficulty of early diagnosis of cholera.—There is no way of distinguishing ordinary simple diarrhœa from the premonitory relaxation of the bowels of cholera, except by a bacteriological examination of the stools. Such examination is, however, quite easy, and in actual cholera shows the bacilli in actively moving swarms, usually in pure culture. Although cholera and camp diarrhœa are distinct diseases, the existence of looseness of the bowels, when cholera prevails, predisposes to it.

In simple diarrhœa the main symptom is relaxation of the bowels, with more or less frequent calls to the stool. Even in infective cholera there may be no further sign of the disease than this. Usually, however, in cholera, the patient soon begins to suffer from cramps in the abdomen and legs, repeated vomiting, the calls to stool become urgent and frequent, the evacuations have the appearance of "rice-water," and the patient rapidly passes into the second, or stage of collapse.

Everyone can help in preventing epidemic cholera.—Every person both in peace times in cantonments and during warfare can do something to prevent the spread of cholera, and help to banish it. Cleanliness of every description is the greatest safeguard against the disease; if barrack-rooms and cook-houses, are kept clean, the air in them pure, the water-supply, food supply, latrines and the soil free from cholera microbes, we cover most of the preventive measures. The same holds equally good for camps.

Precautions against cholera.—The men should live regularly and temperately, taking their accustomed diet. Stale, unripe, or unsound fruit or vegetables, should on no account be eaten. Ripe fruit can do no harm, nor can properly-cooked fresh vegetables Uncooked vegetables should not be eaten. It is advisable to eschew cucumbers and melons as they are often grown in fresh ordure as manure. If cucumbers are eaten they should be sterilised in boiling water, peeled and subsequently taken with vinegar. Neither of these is capable of giving cholera, but a surfeit of them may irritate the bowel and predispose to it. All tainted fish and meat are particularly dangerous at such times. All milk consumed should be pure, or at least sterilised by boiling; people supplying milk from villages on field service frequently water the milk, the water used for this purpose is often impure. If reliably pure milk is not obtainable, condensed milk should be used.

During cholera periods men should not work on empty stomachs. When practicable, the men should be kept engaged in some form of work or amusement without being fatigued.

Boiling and filtering of water is the only reliable way of destroying any cholera bacillus it may contain. During cholera periods it is most dangerous to use water that has not been sterilised and kept sterilised until it is consumed.

Alcoholic intemperance during cholera epidemics invites attacks of the disease—temperance in both eating and drinking is to be enjoined. All chills and checking of perspiration is to be avoided. A flannel shirt should be worn, and at night also a flannel ("cholera") belt, to prevent catching cold in the bowels. All the foregoing precautions apply equally to life in cantonments and camps.

It is very important to avoid foul smells of any kind, specially those of latrine trenches, fouled soil, and collections of camp refuse. The night-soil trenches are to be thoroughly supervised and their contents disinfected several times a day. The ground in and around tents should be kept thoroughly clean. No refuse should be allowed to lie in the camp enclosure, it should be collected in the selected places and burnt; all slops and liquid refuse of kitchens and waste water of ablution places should be disposed of as laid down previously.

The air of tents should be as pure as possible.—The air in the tents should be as pure as possible; the best way to secure this is to keep the doors open, or the side-walls up, avoiding excessive draught and chills.

Early notification of the disease.—Cholera is chiefly curable in the first stage or that of premonitory diarrhœa. It is therefore absolutely necessary that the patient be brought under treatment as soon as diarrhœa commences. The slightest attack of diarrhœa in any form should be attended to at once. As soon as any disturbance of the abdomen occurs, pain, gripes, slight diarrhœa, nausea or sickness, the men should be sent to hospital. This gives the best chance of the man being rapidly cured, and it helps to prevent the spread of the disease to others in his tent and to the force generally.

Disinfection of clothes, bedding, etc.—All infected clothes and bedding should be disinfected at once, put into boiling water and subsequently passed through one of the forms of disinfecting apparatus referred to elsewhere (pp. 425, 426), if the force has been provided with them. If thorough disinfection cannot be guaranteed, it is safest to burn all clothes and bedding used by cholera cases. Metal utensils used by cases should be passed through the fire.

Cholera "contacts."—In cantonments the barrack in which a case of suspected or developed cholera occurs is vacated at once, the patient sent to hospital, and the other occupants, who are called "contacts," are treated as if they were carriers of the disease for ten days, by being isolated in tents and kept under observation; the barracks are fumigated with sulphur dioxide, and washed down throughout with some powerful disinfectant, then thrown open and re-occupation is not allowed for ten days. In camps the tent in which a case of suspected cholera occurs should be vacated at once, the patient sent to the field ambulance and the other occupants who are "contacts" treated as if they were carriers of the disease for ten days (see remarks regarding enteric fever "contacts"), and the tent fumigated with sulphur dioxide, struck, the soil disinfected, and the site not again occupied.

Infectiousness of cholera explained.—Cholera is not literary or otherwise contagious, but it sometimes acquires the qualities of an infectious disease, especially when the microbes are numerous and

their virulence intense, as is usually the case at the beginning of an epidemic, and when certain conditions of weather and locality favour the multiplication of the microbe. As far as tents are concerned, the surest way to preventing the germ affecting the occupants is by good ventilation. The more air that gets in, the fewer the number of germs, and consequently, the smaller the chances of them affecting the men. Cholera bacilli. when in the dried state, are wafted into the air and reach the mouth and throat of those in the neighbourhood of the patient. Hence the precautions necessary of washing the hands and rinsing the mouth and throat on the part of all in attendance on cholera patients before eating or drinking.

Isolation of cholera cases.—Persons suffering from undoubted cholera are, as a matter of course, isolated, and only those absolutely necessary for their care and treatment should be allowed in the vicinity of the tent they occupy. There is no doubt about persons in attendance on cholera patients sometimes getting the infection. One has, personally, had two attacks of it acquired in this way. The reason is obvious when we recognise that the sufferers cannot control either vomiting or purging, that the matters discharged on the ground are like water; the liquid part of the discharges having evaporated the residue is quite invisible, these discharges are laden with virulent cholera microbes and are wafted into the air by every movement of persons about the patient and by every gust of wind.

Fear of cholera a mistake.—During the occurrence of a cholera outbreak there is no special reason for apprehension if the ordinary precautions given above are adopted. Fear and mental emotions tend to depress and predispose to the disease. If we drink sterilised water, breathe pure air, eat wholesome food that has been properly cooked, keep the latrines and night-soil trenches disinfected, and the camp thoroughly clean, we are well defended against this disease.

Purgatives to be avoided.—It is scarcely necessary to emphasise that no person during an outbreak of cholera should take purgative medicines unless specially prescribed by a medical officer.

Healthy persons may be the carriers of cholera bacilli.—As in enteric fever, so in the case of cholera, persons in perfect health may carry the germs of the disease, and discharge them broadcast. Dr. F. GOTSCHLICK, at the plague quarantine camp at Torfor Hadjis, found that of 107 pilgrims who died of different non-cholera diseases, the true cholera vibrio was present in six cases. In these six the serum agglutination reactions (see foot note p. 486) were obtained in high dilutions of the cholera serum; morphological, cultural, and other characteristics of the bacillus were identical with those of the true cholera microbe. These six cases were all in Russians or Turks who had come from districts where cholera had been epidemic, none of the

six had any symptoms of cholera while under observation, nor any indications of having had it. These people had been two months from their homes, during the whole of which time they were probably discharging cholera bacilli broadcast, but no cases of cholera were reported at Tor or in any part of the route to Tor.* One has for years personally known that there are cases of ambulatory cholera in every widespread epidemic of that disease, who go about their ordinary work; and, it is well known to all health officers of large towns in India, that cases of minor diarrhœa occurring during cholera periods are carriers of the true germs of cholera to other persons of the community. These facts present us with a very formidable task, and as it is now shown to be probable that persons, insusceptible themselves to cholera, may yet be the carriers of virulent germs of the disease through their discharges, the problems of the prevention and methods of spread of that disease have a wider range than we have hitherto anticipated, and one makes this remark after having had exceptional experience in investigating the origin and spread of many epidemics of cholera.

Anti-cholera vaccination.—When a force has to run the gauntlet of a cholera epidemic, the advisability of universal inoculation with anti-cholera vaccine before the troops start may have to be considered by the Principal Medical Officer, India. There is much evidence in its favour as a protection against cholera.

If obliged to go to a cholera district, it is advisable to get inoculated against the disease. This is a simple process. It consists of injecting under the skin a specially prepared vaccine, *Haffkine's anti-cholera vaccine*. This consists of a culture of a powerful vaccine made by passing the bacillus through the guinea-pig. It causes slight indisposition with a little fever and headache, and pain at the seat of the inoculation for 24 hours. The inoculation should be carried out before entering the cholera district.

Professor Haffkine's conclusions regarding the effects of his anti-cholera vaccine are:—(1) The protective effect of anti-cholera vaccine commences soon after the operation, and increases rapidly for the first four days, and lasts for about 14 months, after which it rapidly diminishes and probably disappears completely; (2) during the period of its activity, the vaccine reduces the number of cases amongst those protected to less than a tenth of those occurring amongst the unvaccinated; (3) the mortality of those who contract the disease, whether vaccinated or unvaccinated, differs but little, and the course of the disease would appear to be unaffected by the previous inoculation.†

Briefly then protection is obtained by strict attention to the water-supply, food-supply (specially milk), a strict conservancy system in

* *Annual Report of the Sanitary Commissioner with the Government of India*, 1905, p. 84.

† *Journal of the Royal Army Medical Corps*, Journey 1907, p. 109.

which every particle of excreta is disinfected and covered the moment it is evacuated, watchfulness for the earliest signs of the disease in men, who must be compelled to go to hospital at once, and their strict isolation there.

We are now fairly well acquainted with the nature of cholera, its cause and methods of spread or epidemiology, and it is possible in practically all cases in cantonments to prevent its attacking troops epidemically, although the labour in doing so may sometimes be very considerable.

Scurvy—Scorbutus.

Scurvy is a constitutional disease associated with great debility, a spongy condition of the gums, extravasations of blood beneath the skin and into the subcutaneous tissues, a tendency to hæmorrhages from the mucous membranes, fœtor of the breath, and anæmia. There is an impoverished state of the blood, and some change takes place in the walls of the blood vessels which permits of bleeding from them. The disease is specially associated with long continued use of improper and often insufficient food, and it is especially connected with the absence of fresh meat and fruit. It is greatly predisposed to by unhealthy hygienic surroundings, prolonged exposure, and hardship. Outbreaks occasionally occur in troops on field service. Isolated cases of undeveloped scurvy occur throughout India at all seasons.

Diseases from defective diet.—The diseased conditions which may result from defects in the quality and quantity of food are numerous and diverse; these have been partly alluded iu the section on Food, and it is here only necessary to add some remarks about *scurvy*. The condition brought about by ankylostomiasis (a severe form of anæmia due to hook-worms in the small intestine) undoubtedly predisposes to scurvy, and it is by no means uncommon to find both conditions associated in the same patient, especially at the end of the hot weather, and the combination is a grave one. Some authorities believe scurvy to be due to a microbe, but all evidence at present is against such a view. The disease is curable and usually rapidly so. In cases in which bad hygienic conditions and the consumption of improper food continue, death usually results, generally from some intercurrent disease.

Essential cause of scurvy.—The general opinion now held is that scurvy is due to a deficiency of those salts in the food whose acids are converted into carbonates in the blood, that is, of the organic acids—citric, tartaric, lactic, acetic and malic. These we know to be important from a nutritional stand-point. "The salts containing these acids are, to begin with neutral, and afterwards become alkaline from their change into carbonates in the system; thus they play a double part; and moreover, when free and in the presence of albumen and

chloride of sodium, these acids have the power of precipitating albumen or perhaps setting free hydrochloric acid." Whatever their precise action, they are a necessity in the economy. It is the deficiency of these particular acids and salts from diets which causes the blood and fluids of the body to become less alkaline and gives rise to scurvy, and their addition to diets cures scurvy. Sir ALMROTH WRIGHT holds that scurvy is due to an acid intoxication of the blood in which the alkalinity and coagulability of the blood are lessened, arising from a deficiency in the diet of alkaline food. If all fresh vegetable and fruit are excluded from the diet, the acids of a meat diet preponderate over the alkalies of vegetable food taken.

Deficiency of fresh vegetable means a decrease in the salts of the acids named, and if long continued, scurvy follows as an inevitable consequence. Its onset is greatly assisted by supplementary factors, such as actual deficiency of food generally, exposure to cold and wet, moral and mental depression, excessive fatigue, etc. The organic acids alluded to are naturally provided in the juices of fresh succulent vegetables, fresh fruit, tubers and roots. We should remember that *dal*, peas, beans, and other leguminous products have no antiscorbutic value. The potato, onion, tomato, fresh cabbage, and radish are amongst the most useful vegetables against scurvy. It is not generally known that the different varieties of cactus, after being thoroughly cooked by roasting or boiling the soft interior succulent part, may, on emergency, be used to prevent scurvy, and although it is seldom very palatable, if made into soup it may be rendered agreeable.

Scurvy is not due to any germ, and is not communicable from man to man. It may become a serious cause of inefficiency on field service under the influence of defective diet, especially with an absence of fresh vegetables and fresh meat.

Partial starvation aggravates scurvy.—An absolute deficiency in the quantity of food producing partial starvation greatly predisposes to and aggravates scurvy. Associated with this combined condition of partial scurvy, there may be low inflammatory affections of the internal organs, as the lungs or liver, and of the muscles ; dysentery, diarrhœa, etc., which the antiscorbutic regimen does not materially affect, but the scorbutic factor is remedied by it.

Theoretically scurvy is preventable.—Theoretically it may be said that scurvy is quite preventable on field service, and that its occurrence stigmatises the work of the sanitary and supply services in the field. That it can be greatly kept in check in large campaigns was shown by the Prussians in 1870-71 and again by the Japanese in 1904-05. It would seldom occur if the nature of the soldier's diet could be always that of peace times, and its constituents varied in accordance with the principles we have previously referred to.

"At the present day its existence on field service is evidence of lack of efficient sanitary administration and defective transport or short-sighted economy."

Symptoms.—The premonitory signs are—malaise, great debility, langour (bodily and mental), rheumatic-like pains in the limbs and joints generally, breathlessness, dry skin, puffiness under the eyes, ulcers in the mouth or soreness of the tongue, (the gums being as yet unaffected), discoloured patches in the lower limbs and then on the body. Anæmia soon appears. Subcutaneous hæmorrhages, especially in the calves of the legs and in the back of the knee, which are painful, tender and may be extensive; and sometimes bleeding into the joints occurs. Extravasation into the muscles may occur. A diarrhœa with chocolate-like stools may be the first sign. The gums become soft and swollen, bleeding readily on pressure with a tooth-brush or finger to clean the teeth, and they may ulcerate and slough. The breath is very offensive. Slight bruises or injuries bleed. The anæmia increases, the legs become dropsical and the face puffy. The skin is dry and rough and there is the pallor of anæmia. As seen by the medical officer in the early stage, there is usually some swelling and sponginess of the gums, which bleed readily. Scurvy may first present the characters of an attack of rheumatism, or even of a very severe cold. There is mental apathy, lassitude and fatigue is easily produced. Ulcers may form on the legs from trifling injuries or spontaneously. The pulse is rapid and feeble.

Prevention of scurvy.—In the prevention of scurvy the indications are—to supply the salts and acids which have been absent in the dietary, and the avoidance of the accessory or predisposing causes to the disease.

When scurvy threatens lime-juice to be issued daily.—Whenever scurvy threatens and the authorised ration of vegetables is deficient, an ounce of good *lime-juice* should be issued daily, and it should be seen that the men take it. A sufficient supply of lime-juice for this purpose should always accompany the force. Preserved lime-juice is the chief article we are obliged to fall back on in long campaigns; it forms part of our soldier's ration—an ounce daily being given in the absence of fresh vegetables. A supply of lime-juice for this purpose is invariably carried by the Supply and Transport Service.

Dried vegetables as anti-scorbutics.—Dried vegetables are anti-scorbutic, but decidedly inferior to fresh vegetables, as their organic acids are probably to some extent decomposed by heating and keeping. When vegetables are dried and compressed, a large proportion of the acids and salts are removed, and what remains is largely indigestible cellulose. The use of fresh vegetables should not be superseded by preserved or compressed vegetables, if fresh vegetables are procurable.

As a precaution, preserved or dried vegetables should be issued early in a campaign, but should never, if possible, exclude the use of fresh vegetables.

Fresh fruit.—Fresh fruit, especially lemons, limes, oranges, grapes and acid fruits generally, are excellent anti-scorbutics. Even unripe fruit, when cooked, is better than none, and when scurvy threatens, the possible occurrence of diarrhœa from their use may have to be risked. Dried and canned fruits are also valuable. Dried raisins and currants are useful anti-scorbutics, and other dried fruits are probably useful as such.

Fresh meat.—Fresh meat is an excellent anti-scorbutic, especially when not over-cooked. The Esquimaux and Red Indians, who live on meat, either raw or partially cooked, and have often to go without vegetables for long periods, do not get scurvy. KANE in his Arctic Expedition wrote: "Had we plenty of walrus I would laugh at scurvy." Pemmican (see p. 200) consisting of fat, sugar, raisins and currants, is an excellent antiscorbutic for cold climates, and is much used by Arctic explorers and travellers generally in the Far North and South.

Vinegar.—Vinegar consisting largely of acetic acid has long been known to prevent, and even cure, scurvy. It is very inferior to citric and tartaric acid, probably because it is not combined with an alkaline salt. Citric and tartaric acids are the special anti-scorbutics upon which we rely, but not in their pure chemical form. Vinegar, half an ounce to an ounce daily, may be used for this purpose in the process of cooking food, or taken with pickles. The Romans probably owed their immunity from scurvy to it, and it was a recognised anti-scorbutic in both armies of the American Civil War of 1862—64.

Of the anti-scorbutic fruits, vegetables, etc., obtainable in India we may mention—oranges, lemons, limes, grapes, pummaloes, pickles, vinegar, onions, cabbage, turnips, potatoes, brocolli, radishes, mustard and cress. The fresh 'milk' of the cocoanut is said to be highly antiscorbutic. Potatoes, which may always be obtained, are one of the best anti-scorbutic vegetables. Amongst other anti-scorbutics that may be used are—tamarind juice (an ounce of the dried tamarind fruit being used to a pint of water, as a drink or cooked with the food, decoction of pomegranate or bael fruit, *amchur* or *khattai* (dried and sliced mangoes) 1 ounce daily, powdered and used with soups and vegetable. "In time of war every vegetable should be used which it is safe to use, and when made into soups, almost all are tolerably pleasant to eat."

Beer and red wines.—Good beer and red wines are credited with anti-scorbutic virtues.

Scurvy gives rise to over 200 admissions yearly, and is a condition for which medical officers of Native units should be on the look out, especially during the hot weather when the supply of vegetables runs short.

It is impossible to emphasise the importance of recognising the possibility of widespread scurvy occurring in improperly rationed armies. The gruesome story of the history of that disease during

the last days before the capitulation of Port Arthur is fresh in the memory of all readers of military history. Indeed its terrible ravages are stated by some authorities to be one of the immediate causes for the surrender of that fortress (see p. 39).

A form of latent or undeveloped scurvy is very common in India, and is at the root of much disease. A small degree of scurvy may exist for a long time without active symptoms. Its first indication may be dropsy of the feet and legs or bruising of the surface from slight causes may be the only sign. The slow healing of wounds, or wounds bleeding readily, is another. The condition dealt with in the next article is also an undeveloped form of scurvy that is indirectly the cause of much sickness.

Ulcerated, Swollen, and Spongy Gums.

Nature of this condition.—One would take this opportunity of inviting attention to the great prevalence of a condition of the gums which arises during our Indian Frontier campaigns, especially those lasting over four months, *i.e.*, to a state of ulceration, sponginess, and swelling of the gums; and frequently associated with this we find the mucous membranes of the tongue, cheeks, and mouth generally, more or less denuded of epithelium, or presenting small visible ulcers here and there. Accompanying this there is often a more or less septic condition of the mouth.

Its widespread occurrence in India.—This condition is very widespread in some parts of India at certain seasons of the year; it is especially associated with periods of drought and scarcity. One can recall finding it in three out of five Native regiments at one time in the Deccan, and at the end of the Tirah Campaign, cases of it were to be met in most Native regiments. It is painless, often the man does not know that anything is the matter, and he rarely comes to hospital for it spontaneously. It is, in general appearance, at first sight, similar to what dentists call pus from the teeth sockets (*Piarrhœa alveolaris*), a very chronic and somewhat formidable malady leading to atrophy of the gums, loosening, and eventually falling out of the teeth. This is not the case in the condition under reference. A week's treatment after returning from field service, or a few week's treatment when on service, and the men recover completely without any loss of teeth. It is also very similar to what one sees in the incipient stage of scurvy, and is occasionally associated with the more positive manifestation of the scorbutic state, such as hæmorrhage from the mucous membranes, anæmia, dysentery, etc. It likewise responds to local treatment and antiscorbutic measures. It seems in Indian warfare to precede the appearance of the actual classical signs of scurvy. It was very prevalent in Somaliland in 1903-04 before the outbreak of *actual* scurvy. Yet there is little in this state to justify one's calling it scurvy. Personally I am inclined to consider this an ante-scorbutic manifestation.

It is insiduous in its onset, and, while it lasts, renders its victim liable to any one of the numerous maladies of the air-passages and bowels which may be associated with oral sepsis. Apart from the inhaling, or ingestion of germs of actual specific disease, the constant absorption of the products of sepsis and putrefaction—germs and toxins—from the disease-surface, must produce a general lessening of vitality and lowered resistance to disease-causes generally, a point deserving of special attention. In the state of perfect health, we know that the mouth and nasal passages are the happy hunting grounds for many disease-producing germs. With the normal condition of the mucous membranes of the lungs and bowels, the germs reaching them produce no evil consequences—the reverse may be the case, however, when these mucous membranes are in any way damaged, their resistance to invasion being then lowered. The many varieties of bacilli and cocci that are more or less constantly present on the surface of the body, in the mouth, air-passages, alimentary tract—germs of pneumonia, dysentery, enteric fever, etc.—usually operate on barren soil in thoroughly healthy men, the cells of the tissues being then in their highest state of physiological defence and antagonism.

It is remediable.—As previously stated the condition is remediable. Its appearance in any regiment is an indication that there is something defective in the feeding of the men, and as a rule it will be found that the men are living on a monotonous diet, consisting chiefly of rice, or *atta* and *dal*, with little or no vegetables or fresh meat.

Whilst it occasionally occurs in emaciated and anæmic men, it is sometimes found in well-nourished men. It is one indication of commencing defective nutrition and should be taken as a timely warning of there being some defect in the quality of the food.

Preventive and curative measures.—In an epidemic of this condition in a Native infantry regiment which one had to investigate and report on not long ago, the following recommendations were made :—

1. An issue of an ounce of lime-juice daily for a period of one month, and if the condition has not considerably abated by that time, a further issue of an ounce twice a week for another month.

2. The daily use of at least eight ounces of fresh vegetables (preferably potatoes and onions), for one month, and a similar quantity at least three times a week for three months, after that period.

3. The use of eight ounces of fresh meat per man twice a week.

4. The issue of half an once of *amchur* and of dried tamarinds (*imli*) on alternate days, to be cooked with the food.

5. The compulsory use of *atta* instead of rice for at least three days in the week, for the ensuing two months.

6. That the men be advised as to the necessity of thoroughly cleaning their teeth daily.

7. The attendance at the hospital daily of all cases of swollen spongy or ulcerated gums for (local, and if necessary general) treatment—these cases need not be admitted into hospital, nor struck off duty for the purpose of attending hospital.

8. The medical officer of the regiment to make a weekly medical inspection of the whole regiment, and report the result of the measures suggested.

These suggestions would hold equally good on field service.

The condition of the mouth and gums of all troops requires constant watchfulness. Wherever there is a prevalence of a diseased condition in these regions there will also be an increase of diarrhœa, dysentery and alimentary troubles.

Chronic Rheumatism.

This sometimes follows one or several attacks of acute rheumatism, some joint or joints remaining stiff, painful, and enlarged, but usually it occurs as an independent disease. Sometimes it comes on insidiously and is progressive from the beginning; the function of the implicated joints are impaired, there is wasting of the muscles adjacent to the joints from want of use, and the condition is much influenced by meteorological changes. It is especially common amongst the impoverished middle-aged soldiers approaching their time for pension. The real nature of this affection is not as yet completely understood. The fibrous structures around joints, the sheaths of muscles, tendons, fibrous coverings of nerves and of bones may all be affected; these may become inflamed, but there is little alteration in structure manifested, and this even when joints are involved, though they usually become stiff and limited in their movements.

Symptoms.—The chief are—pain, tenderness and stiffness in the parts involved. The pain is worse on movement, although carefully adjusted and systematic exercise frequently lessens and sometimes completely removes the pain. In a joint there may be slight swelling, which after a few days' rest may disappear. The pain is usually localised.

Prevention.—There is a special tendency for the disease to occur in some men, and little can be done in the way of prevention.

Acute Bronchitis.

This is an acute inflammation of the mucous membrane of the bronchial tubes usually due to exposure to cold, the inhalation of irritating dust or to certain infectious agents.

Symptoms.—The disease begins with symptoms of a common cold, pains about the chest and cough. The pain is usually associated with a feeling of rawness or soreness located behind the breast-plate. The expectoration, at first scanty and frothy, later becomes thick and yellow, when the pain in the chest abates or disappears There is difficulty of breathing. Wheezing noises are heard all over the chest, and as peculiar thrill is felt when the chest contains phlegm, this disappears when the phlegm is coughed up, and reappears when it again accumulates This arises from the air mixing with the mucous contained in the bronchial tubes. There is fever, but the temperature seldom goes beyond 101° F., and the skin is

moist. The urine is scanty and high-coloured. At the end of three or four days the fever and the more acute symptoms gradually subside, convalesence being rather slowly established. If the case is getting worse the previous difficulty of breathing becomes more pronounced, the lips become purple, the fever continues; this usually arises from extension of the disease to the smaller bronchial tubes (p. 138). Bronchitis is frequently a terminal disease in chronic malarial infection, malarial cachexia (p. 463), kala-azar (p. 482), and other fevers and is then often fatal, especially in the cold weather, and in places where there is great difference in the meteorological temperature between day and night.

Prevention.—The general measures for the prevention of bronchitis are:—avoidance of causes of chills, especially remaining in clothes that have been rendered moist by rain, athletic exercises, or games; the regular use of flannel shirts, and free ventilation of barracks and tents. Soldiers who have a special tendency to bronchitis should during the intervals between the attacks practice deep breathing exercises (pp. 47, 48), sleep in the open under mosquito curtains, gradually accustom themselves to a cold bath daily, and avoid the use of heavy outer garments and mufflers, which make the skin highly sensitive to changes of weather.

PNEUMONIA.

Synonyms.—Acute Croupous Pneumonia; Lobar Pneumonia

These are the terms applied to an acute infectious fever characterised by an inflammation of one or more lobes of the lung (or of both lungs), the affected part of the lung being rendered solid owing to the exudation of fibrin and white blood cells into the air sacs (p. 139). The exciting cause is generally a special diplococcus (*Diplococcus pneumoniæ* of Fraenkel), but other micro-organisms may very occasionally produce it.

The diplococcus of pneumonia is one of the ordinary inhabitants of the mouth and nasal passages, and although we frequently inhale it from these passages, so long as we are in perfect health, it does not multiply to any extent in the lungs. It is one of the most widely distributed and most fatal of the acute infectious diseases of this country—this remark refers specially to the unseen and untreated cases that occur in Indian villages, although a higher proportion of cases occur in town. All debilitating influences predispose to it. Pneumonia frequently occurs after exposure to cold which predisposes to the disease

Pneumonia on field service.—In some of our Frontier wars pneumonia has been the cause of considerable mortality. There have been, curiously, other campaigns in the same regions where the incidence of pneumonia was an almost negligible factor. The same disparity is visible in the statistics of our large manœuvres. During the Delhi Manœuvres in November and December 1902, we received a large number of cases into the Native General Hospital. In the Rawalpindi Manœuvres of 1905, during the ten days the Native

General Hospital was open, we received only five cases, although the forces were bivouacking for several nights. It is fairly established that exposure and bivouacking, when not too prolonged, with reasonable precautions can, in a trained force, be carried out without harm to the health of the men. It is moderately certain that pneumonia acquires in some campaigns and manœuvres an epidemic intensity, and that the virulence of the special microbes causing it increases when this is the case. Under ordinary circumstances, we look upon this disease as an acute specific fever in which the dominant symptoms are manifested on the heart and lungs.

The admission and death rates amongst European troops in 1907 from this disease were 2·8 and 0·35 respectively per 1,000 of strength, the total admission being 195 and deaths 241; in 1908 the admission and death rates where 3·9 and 2·2, the total admissions being 269 with 27 deaths, and in 1909 the admission and death rates were 2·9 and 0·31, there being 209 admissions with 22 deaths In the Native Army in 1907 the admission and death rates were 12·4 and 1 99 respectively per 1,000 of strength; in 1908 the admission and death rates were 12·8 and 2·20 respectively, and in 1909, the admission and death rates were 11·8 and 1·88.

Symptoms.—The disease sets in suddenly with a chill or series of rigors, the temperature rising rapidly to 103° or 104° F., the respirations increase to from 30 to 50 or more in the minute, while the pulse is not proportionately accelerated. There is at first a slight cough with scanty spit which is viscid, but it soon becomes rusty-coloured and contains some blood and crowds of the causative germs. There is difficulty of breathing, and the cheeks are flushed. The cough increases, the expectoration is larger in quantity, more tinged with blood and less sticky. There is pain in the side of the chest affected, usually below the nipple and armpit, which is increased on coughing and during deep breathing. The tongue is coated, there is thirst, loss of appetite and there may be delirium. An eruption of small blisters may appear on the lips between the 2nd and 5th days. These symptoms go on for from 5 to 7 or 9 or even 11 days, and suddenly subside (crisis), profuse perspiration occurs, and the temperature drops. The cough continues and the expectoration becomes less blood-tinged and now consists of a frothy yellowish material. The urine, which was scanty, becomes normal or excessive in quantity, and the chlorides in the urine which were very considerably decreased, are now increased beyond the normal.

Resolution may not take place or only be partial, or suppuration or gangrene of the lung may occur, or during the height of the disease the patient may die from heart failure. In the aged and those of alcoholic habits the disease is always dangerous.

Pleurisy more or less is practically invariably present, and sometimes large effusions are poured out into the pleural cavity (see p. 139). Inflammation of the pericardium (p. 143), or of the membranes of the brain, may occur as a complication.

The crisis may be any day between the 3rd and 11th day, most frequently on the 5th or 7th. The characteristic sign is the rusty sputum, but rarely some pneumonia cases have no expectoration, and still more rarely it is whitish-yellow. Every case of pneumonia, from the mildest form to the most severe, is a serious disease. The amount of blood-poisoning is by no means in proportion to the extent of lung tissue involved. A small amount of lung disease may be associated with intense blood poisoning and *vice versâ*, and a mild attack may at any time become dangerous from complications setting in.

Prevention.—The soundest prophylactic means are good ventilation, healthy living, avoidance of chills and cleanliness of the mouth and teeth. The strongest predisposing factors in bringing about pneumonia are closeness, overcrowding, and bad ventilation. Cases of pneumonia should as far as practicable be isolated, and their expectoration, which swarms with the germs of the disease, should be disinfected.

FAINTING OR SYNCOPE.

Fainting usually begins with a feeling of giddiness and that everything is going round ; there is some fluttering of the heart, followed by pallor of the face ; the pulse is weak, the breathing quick, a cold sweat occurs on the face and hands, the person staggers and then falls to the ground more or less unconscious for few a minutes or so.

Fainting arises from a diminished supply of blood to the brain due to temporary weakness of the heart. The main object is to restore the circulation of the brain to its normal condition. Hence we lay the patient flat on the back, loose all tight clothing about the body and neck, give plenty of fresh air, sprinkle or dash cold water on the face, apply smelling salts to the nose, rub the limbs, and when able to swallow give a teaspoonful of sal volatile in a wineglassful of water, or a little brandy or whisky and water, and let the patient remain recumbent for a while after recovering consciousness. If the faint continues apply warm bottles or some other form of warmth to the feet, a mustard plaster over the region of the heart, and if the breathing threatens to stop artificial respiration is to be carried out.

Prevention.—A sound system of physical training, the avoidance of overfatigue in the case of men who have run down from any cause, and watching for the earliest stage of disease amongst men in the ranks are the best means of preventing cases of fainting.

DIARRHŒA.

Diarrhœa is a condition characterised by increased frequency and decreased consistency in the evacuations from the bowels. This increased discharge of fæces may arise from an increased amount of intestinal secretions or by anything that excites peristaltic action. Apart from actual disease of the intestines, the most frequent causes of diarrhœa are eating improper food, indigestible food, excess of food, food that is decomposing or improperly cooked or incompletely chewed, unripe fruit, drinking cold liquids, especially when over-heated, excitements of the nervous system, sudden exposure to heat or cold, worms in the bowel, and the injudicious use of purgatives. It may also arise from unhygienic surroundings, breathing impure air, especially the foul air from fæcal decomposition. Not unfrequently it is produced by exposure to cold, sudden checking of perspiration, abdominal chill acquired at night, keeping on wet clothes, drinking cold iced or acid drinks when the body is overheated. It is specially prevalent in neglected standing camps. Infected flies and dust are probably instrumental in carrying the disease to the healthy. Food, milk, and water require special attention, and latrine trenches should be closely watched and properly looked after.

Diarrhœa may also be the earliest sign of infective diarrhœa or dysentery; it may be associated with malarial infection, kala-azar, and various forms of septic poisoning; it may occur during the crisis of some acute diseases; it is a prominent symptom in typhoid fever, sprue, hill diarrhœa, chronic catarrh of the bowels, etc.

Whilst improper feeding is the cause of many cases of diarrhœa and intestinal disturbance, it probably causes much more sickness and mortality indirectly by preparing the mucous membrane of the alimentary tract for the ravages of a specific microbe having many characters similar to the different species of the bacillus of epidemic dysentery.

Amongst European troops *diarrhœa* was responsible for 1,217 admissions with 1 death in 1908, and 896 with 1 death in 1909. In the Native Army it gave rise to 1,115 admissions with 8 deaths in 1908, and 1,005 admissions with 5 deaths in 1909. Diarrhœa is one of the most frequent causes of inefficiency on field service, both when on the move and in standing camps. In the returns "diarrhœa" includes also cases of infective diarrhœa which is a much more serious condition.

Symptoms.—The usual symptoms are large and more frequent motions than normal, which are reduced in consistency; there is discomfort and flatulency, often distension of the abdomen, and sometimes colicky pains, nausea or actual vomiting. There is thirst, scanty urine, and a feeling of weakness, which in severe cases may be extreme. The number of stools may vary from 3 or 4 to 20 in the day.

The condition may be acute, subacute, or chronic, and in the chronic form gives rise to anæmia and emaciation. To recognise the nature of the diarrhœa it is necessary to ascertain how it began, the amount of pain and tenderness in the abdomen during and after relieving the bowels, and to note the consistency, colour and smell of the stools, and observe their other characters.

Epidemic diarrhœa—infective diarrhœa—infective enteritis.—*Epidemic diarrhœa* is an infective form of inflammation of the gastro-intestinal tract caused usually by one or other of the dysentery bacilli (sometimes more than one species being present in the same case), and characterised by vomiting, diarrhœa, fever, and great thirst. On field service it causes no inconsiderable loss to the force, chiefly from men being obliged to go on the sick list for it. The disease may affect many persons at the same time and place, and is therefore included in the category of epidemic infective diseases.

In India it gives rise to very serious epidemics, especially in the summer, but it occurs also endemically, almost everywhere, and may occur throughout the year. The infecting microbe reaches the alimentary tract in the same way as those of dysentery and enteric fever, and the preventive measures are almost identical and based on the same principles as in these diseases. In about 70 per cent. of the cases in which it has been looked for, one or other form of dysentery bacillus has been found. At present we may say that no single microbe is found to be definitely and invariably associated with this condition, and it would appear that in some cases at least, the disease arises from the combined activities of a number of bacterial forms, some of which belong to well-known species of ordinary occurrence

and wide distribution. In cases in which blood and *mucus* * appears in the stools, the *bacillus dysenteriæ* (Flexner or Shiga-Kruse type) are usually to be found. When the motions are very offensive, it is probable that one of the Proteus group may be incriminated, especially the *bacillus proteus*.

There is little resemblence in the majority of cases between epidemic diarrhœa and epidemic dysentery except in the nature of the infective bacilli. The difference in their symptoms and effects on the bowels would point to their being distinct and independent diseases. The effects on the walls of the bowels of epidemic diarrhœa varies very considerably, whereas those of bacillary dysentery differ from each other only in degree. It is possible that the condition may arise from different species of micro-organisms; for the present we must consider the subject of the causation of the disease *sub judice*. Of one thing we are practically certain—it is bacterial in origin.

It is largely due to drinking water containing the germ or germs of the disease, or the milk contaminated with such water, or to food contaminated by dust or flies carrying the germs.

"The essential cause of epidemic diarrhœa resides ordinarily in the superficial layer of the earth, where it is intimately associated with the life processes of some micro-organism not yet isolated. The vital manifestations of such organism are dependent among other things, perhaps principally upon conditions of season, and on the presence of dead organic matter which is its pabulum."

It is predisposed to by hot weather and unhygienic surroundings. The incubation period is short, varying from a few hours to a few days. The infective agent is in all probability contained in the excreta of those suffering from the disease.

Symptoms.—It is usually preceded for a day or two by simple diarrhœa or other signs of disturbance in the alimentary tract, but it may come on quite suddenly. Violent and almost incessant vomiting and diarrhœa occur simultaneously with restlessness and irritability; the skin is hot and dry and there is extreme thirst which is usually one of the most obvious signs. Phenomena of fever, the temperature ranges from 102° F. to 104° F., and often pains in the abdomen, the breathing is embarrassed and the urine may be reduced or even suppressed. The stools may become extremely loose and watery; there is rapid loss of bulk and great exhaustion, and children may become more or less collapsed, with cold extremities, pinched face, shrunken abdomen and very feeble and frequent pulse. In other cases the stools are very frequent and small, and about a teaspoonful of bloody mucus being passed each time, the temperature runs up to 104° F. or 105° F.

The most striking features of the disease are the diarrhœa, thirst, rapid reduction in the bulk of the body, and the extreme prostration.

Prevention.—The chief means of preventing this disease is the thorough drainage of the soil, prevention of surface pollution, proper scavenging and watering of streets and roads of cantonments; proper conservancy arrangements which will ensure that the excreta of all cases of the disease are removed expeditiously and disinfected and incinerated; sterilisation of all milk-supplies, and careful attention to the storage of all foods.

* *Mucus* is a viscid animal fluid secreted by the mucous membranes, and is best exemplified by that from the mucous membranes of the nose and bronchial tubes. In health it covers the mucus membranes, and serves to moisten and defend them, but when these membranes are inflamed the quantity formed may be very excessive.

All milk during the hot weather should be sterilised. As the germs of the disease are contained in the discharges of patients, every precaution must be taken to effect the destruction of all bacilli leaving patients suffering from the disease, and of preventing these bacilli in any way, directly or indirectly, getting to the water-supply, the food, or the air. In the early stage of an epidemic the spread of the disease may as a rule be readily stopped. Several cases of diarrhœa at the same time in the same locality call for special enquiry as to their cause. In most cases it is possible to find such a cause and to either remove it, or the conditions giving rise to it. In this investigation the medical officer should, when necessary, avail himself of the assistance of the sanitary officer of the brigade or division, whose special skill will often be found most helpful.

Dysentery.

Dysentery is the term applied to a group of diseases associated with inflammation of the large intestine, and characterised by pain in the abdomen, frequent calls to stool with the discharge of blood and mucus, much straining, griping pain in the abdomen, and usually with fever.

The different forms of dysentery are now classified, according to their cause, into—(1) *bacillary* or *epidemic dysentery*, due to one of several species of bacilli which gain access to the bowel; (2), *endemic* or *amœbic dysentery*, due to a particular variety of amœba affecting the large bowel; and (3) *sporadic*, not arising, as far as we know, from a specific cause. All these varieties occur throughout India, the bacillary form being by far the most prevalent. The *predisposing causes* of all forms of dysentery are chill, exposure to vicissitudes of weather, attacks of indigestion, or the irritation of indigestible food, defective diet, etc. These prepare the way for the attack of the special bacillus or amœba, or arouse virulence in the activity of the normal flora of the bowels.

Symptoms.—The symptoms *common to all acute cases of dysentery* are as follows:—After what appears to be an ordinary attack of diarrhœa lasting a day or so, the calls to stool become more numerous and mucus is contained in the stools; then the mucus becomes tinged with blood, the stools now having a pink or reddish colour from the mixed blood. There are griping pains in the abdomen, straining at stool and an increasing inclination to evacuate the bowels, so that the patient may be using the bed-pan or commode every ten minutes or so. The stools now contain no fæces; with each evacuation about a tablespoonful or less of blood-stained offensive jelly-like stuff is passed with great straining. The tongue is coated and furred, and there may be some nausea, especially in the early stage. There is usually tenderness of the abdomen, especially low down on the left side. The pulse may become small and frequent. There is as a rule some fever, except in the mildest and most severe forms. In this latter, the temperature may be sub-normal. These symptoms continue for a varying time, but, as a rule, within a week they abate, blood and mucus decreasing, the stools being less frequent and gaining in consistency, the griping is less and the straining gradually ceases. If at the end of a week these signs of improvement do not occur, the symptoms may undergo great aggravation. The calls to stool are incessant and the stuff

discharged consists of shreddy-looking material of chocolate colour which is horribly offensive. The tongue is red, or covered with a brown fur, the teeth are covered with dirt accumulated from the mouth and saliva, the abdomen is distended and tender, and there may be bleeding from the bowel. The temperature usually rises to 103° F. or even to 105° F., the pulse is very rapid, small and weak, there may be continued hiccough, and death from coma gradually sets in.

Dysentery may end in speedy convalescence which is the most frequent occurrence in cases properly treated in the early stage, in chronic dysentery associated with permanent injury to the bowels, or in death from collapse, from hæmorrhage from the bowel, from peritonitis caused occasionally by perforation, from exhaustion, or the "typhoid state."

Sporadic dysentery.—This form occurs everywhere in India, even in the higher hill stations, and is due to one of several causes. Irritation from improper or defectively cooked raw vegetables, or imperfectly masticated food, especially when this is continued for some time, the normal germs of the bowels taking on virulent properties, especially the common colon bacillus, although probably other bacilli (unconnected with the true bacilli of epidemic dysentery) and micrococci, may also operate in bringing about sporadic dysentery.

Symptoms.—In sporadic dysentery the symptoms are as a rule confined to those of the early stage of ordinary bacillary dysentery. The patient has usually suffered from alimentary disturbance for a day or so, mostly in the form of diarrhœa and pains in the abdomen; rarely constipation precedes the attack. Then the stools increase in number, contain little fæcal matter, and some bloody mucus, which is discharged with straining. There are griping pains in the abdomen which precede and accompany the calls to stool. The symptoms are acute while they last. There is little constitutional disturbance, rarely any fever, and no after-effects. It seldom produces more than congestion and catarrh of parts of the large bowel. There is practically always a premonitory diarrhœa with loose feculent motions and foul tongue.

Prevention.—Avoidance of the causes enumerated above is all that is necessary to prevent this form of dysentery.

Epidemic or Bacillary Dysentery.

This occurs throughout the plains of India on the hills, and even on some of the higher hill stations; it is due to one of the several varieties of dysentery bacilli. Epidemic dysentery arises from drinking water or milk contaminated with the germs of the disease, or from the germs gaining access to food from dust, or through flies which have been in contact with dysentery stools. Alcoholic indulgence, especially in conjunction with excess of animal food, greatly predisposes to it; tinned provisions, insufficiently cooked food, unsound fruit, long continued monotonous diet, camping in irrigated land, or near large marshes during certain seasons, and on old camping grounds, may be associated with the disease. Whilst epidemic and amœbic dysentery and malarial fevers ordinarily occur during the same seasons in the same places, they have no relation to one another, and arise from distinct specific causes.*

* We exclude from the ordinary forms of dysentery that variety of it which occurs as a complication of kala-azar, in which a special animal parasite (*Leishmania-donovani*) may be found in the fæces and in the ulcers of the bowels *post-mortem*.

Prevalence.—One of the great enemies of large armies in campaigns used to be, and in the tropics continues to be, *bacillary dysentery*. The records of all our Eastern wars show this; and those of comparatively recent date—Chin-Lushai, Malakand, Tirah, Mahsud, etc., show that it may still be a serious cause of mortality and inefficiency. Dysentery is a disease which, in European troops next to enteric fever, almost invariably claims most victims in war; in South Africa there were 31,363 cases, with 1,248 deaths, and the Japanese in Manchuria had 1,804 deaths. In Native troops and followers in Indian Frontier warfare it is the chief cause of mortality.

The Americans in the Philippines continue to suffer severely from it, notwithstanding that in connection with this particular disease medical scientists of America have done probably more than those of any other nation to fathom the exact cause of the disease. It is possible that we are approaching the time when anti-dysenteric sera—curative and prophylactic—may deprive the disease of its terrors, but for the present we can only act in the direction of endeavouring to prevent it, and when it occurs, endeavour to exterminate it.

Dysentery gave rise to 4,728 admissions in 1908 with 28 deaths in the Native Army, and 992 admissions with 29 deaths amongst European troops. In 1909 there were 801 deaths with 18 deaths amongst European troops; in the Native Army there were 4,181 admissions with 19 deaths.

The incidence of *dysentery* has gone down progressively with that of enteric fever amongst European troops, showing that it possibly has similar methods of spread.

The chief varieties of dysentery bacilli are not easy to distinguish by their morphological characters from one another, but they are readily differentiated by the reactions they produce on different forms of sugar. Thus the common dysentery bacillus of India, Shiga-Kruse, ferments glucose only, that of the Philippines—Flexner-Strong, ferments mannite and saccharose. Up to the present time at least eight different species of dysentery bacilli have been discovered and described, each of which is capable of being agglutinated (see foot-note, p. 486) only by the serum of patients suffering from dysentery due to its own strain. In the case of some of these species typical attacks of dysentery have occurred in man by feeding on the pure cultures, the bacilli being again recovered from the blood and mucus in the stools. The dysentery bacillus, like the common colon bacillus, is short, with rounded ends; it is non-motile and it acts upon nutrient media containing certain forms of sugar in a specific way. Each variety has minor morphological differences, but certain definite reactions to nutrient media and sugars. There are several bacilli allied to these (called para-dysentery bacilli), which are capable of producing similar symptoms, only milder.

There is some evidence to show that the bacilli of dysentery may live in the healthy alimentary canal for some time without causing any symptoms of the disease, until the resistance of the person harbouring them is lowered by a chill, some alimentary disturbance from defective food, etc., when they rapidly multiply, possibly acquire increased virulence, and attack the lining membrane of the large bowel

vigorously. When the disease is in a widespread epidemic form it is possible that these germs are contained in the bowels of a large number of healthy persons, ready to light up the disease as above stated. All these healthy persons are real "carriers" of the disease, their stools containing the germs.

There is no doubt as to the real cause of epidemic dysentery—it is due to one or other species of the bacillus dysenteriæ. The disease has been experimentally produced in cats and rabbits by the introduction of pure cultures of these bacilli, both by subcutaneous injection and by injection into the rectum. It has also been produced by the accidental and intentional drinking of pure cultures of the bacilli by human beings.

Bacillary dysentery is in the vast majority of cases a local disease, that is one affecting the bowels; it is only exceptionally that toxins are absorbed from the alimentary tract giving rise to a poisoning of the system.

We do not know how long the *bacillus dysenteriæ* can live outside the body, but it can live for some time in soil polluted with excreta, and also in water and other fluids.

Flies carry dysentery germs and may infect food and water in the same way they do in typhoid fever and infective diarrhœa.

The bedding and clothing of men suffering from the disease become highly infective and may communicate the disease to other men using them. Flies are active carriers of the infection. The channels by which the specific germs reach the bowel are the same as in the case of typhoid fever.

A polluted camp site is one of the most prolific sources of dysentery on field service, and it may lead to widespread epidemic of the disease.

Increase in numbers with length of campaign.—One's personal experience is that it is always one of our most formidable enemies, and the ratio of inefficiency and mortality arising from it after a certain period on field service, rises with leaps and bounds. This is particularly the case when camps are stationary. It would seem that the whole soil and atmosphere of stationary camps may become impregnated with the virus of what has long been known as *camp dysentery*. The conditions of Indian Frontier warfare would appear to have, *ab initio*, the tendency to create a vulnerability in the alimentary tract to invasion of the various dysenteric micro-organisms almost from the commencement of campaigns; it would seem that the whole effect of such agencies as chills, over-fatigue, exhaustion, exposure, impure water, defective food, etc., is to lower the resisting power of the mucous membrane of the intestines to the action of the specific organisms giving rise to this form of dysentery. One has been in a standing camp on field service in which in a period of three weeks 356

of 2,100 men acquired this form of dysentery, including three of the four medical officers looking after the sick, all the sweepers and 75 per cent. of the sick attendants. The water-supply was from a stream ¾ mile away from the camp and appeared to be of excellent quality. The type of the disease was very virulent. No military medical officer of experience in India will refute the infectivity of epidemic dysentery; this is a fact established by the records of all our larger jails and hospitals, and the history of all our prolonged Indian Frontier campaigns. Hence the necessity of keeping all cases of epidemic dysentery isolated.

In cantonments bacillary dysentery may become a very grave cause of inefficiency. This is particularly the case in stations where the disease exists as an *endemic* disease, which at certain seasons becomes epidemic, probably from increased numbers and greater virulence of the causative bacillus.

Continuous residence in a dysenteric district does not give immunity—it renders those inhabiting such places more liable. Similarly, previous attacks increase the susceptibility to future attacks, relapses are occasionally met with, but not to the same extent as in amœbic dysentery.

Symptoms.—This form is usually acute in its onset, and the constitutional symptoms sometimes severe; it may, however, occasionally be preceded by diarrhœa for a few days. The symptoms as a rule begin suddenly; there is fever, the temperature ranging from 100° to 103° F. (or higher) which lasts from three to seven days or so. There are the usual dysentery symptoms—frequent calls to stool with discharge of blood and mucus, straining, and griping pains in the abdomen. Some cases, for some unknown reason, and without the least apparent cause, go on to produce extensive ulceration of the bowel. In some cases the dysenteric symptoms are very intense, becoming more and more aggravated for days and then the patient collapses and dies.

Rarely toxæmia or blood poisoning occurs, and causes death. Relapses are rare except when excited by indiscretions in diet. There are no sequelæ. When blood and mucus disappear from the motions, the discharge of blackish or reddish foul-smelling fluid fæces is of bad omen. If the temperature runs down below normal and there are cold sweats with sunken features, involuntary evacuations, and cessation of pain, hiccough and prostration, the prognosis is very unfavourable. Severe dysentery always produces ulceration of the bowels.

Anti-dysenteric serum of the proper strain of bacillus, especially that causing the disease in the patient, is the most useful. The use of this serum reduces the severity of the symptoms, expedites the cure, and certainly reduces the mortality. It is possible that we are approaching the time when anti-dysenteric sera—curative and prophylactic—may deprive the disease of its terrors.

Prevention.—The prevention is the same as for enteric fever and cholera with reference to water, milk and food generally. All motions

are to be disinfected and protected from flies. Attention to the food-supply is necessary; it should be properly cooked and digestible. Stale, fermenting or decomposed food, unsound tinned provisions, unripe fruit and raw vegetables, should be eschewed. A cholera belt safeguards the abdomen from chills, particularly at night. Fatigue should be avoided. Strict attention to the sanitation of barracks and camps, especially as regards the systematic removal of excreta, is important. All excreta of dysentery patients should be incinerated.

Dangers of dysentery and enteric fever with a force.—It is undoubted that the existence of cases of enteric fever, dysentery, diarrhœa, etc., in the vicinity of the force is a positive, immediate, and serious danger. Such measures of isolation and disinfection as can be adopted cannot be relied on to stop their spread in the force; the indication being to remove every such case to the base hospitals or field ambulances away from the force, with all possible expedition. The longer such cases are retained in the immediate neighbourhood of the force, the wider becomes the area infected, and the larger the number of fresh cases and new foci whence dissemination may spread. This early removal also gives the patients themselves the best chance of recovery. The organisation and resources of field ambulances with the fighting line are not such as give to serious cases of enteric fever aud dysentery the close medical attention, nursing, dieting, and care that they require. Whilst these facts are generally admitted, in actual practice we find that, for one reason or another, it becomes impracticable to remove such cases to the base before they become a source of danger to the healthy.

Conclusions arrived at regarding dysentery.—Several inferences are forced upon one in this relationship: (1) Every endeavour should be constantly made to guard against camp dysentery from the beginning of a campaign, as it soon becomes a soil disease and thereby permeates the air that is breathed, and the food and drink consumed; (2) it acquires what, for practical purposes, might be considered infectious qualities; (3) the essential causative agents, dysentery bacilli, are contained in the dejecta of patients suffering from it; (4) these bacilli must be destroyed and rendered innocuous as soou as possible by disinfectants and subsequent incineration; (5) early detection and segregation cases; (6) as the presence of such cases is a danger to the healthy part of the force, all these cases should be sent to hospital at once and returned to the base at the earliest possible opportunity; there should be every attention given to the disposal of the excreta, and to protection of the water-supply and food from specific infection.

Amœbic Dysentery.

Amœbic dysentery is specially common in the whole of the Deccan. In the Afsul Gunj Hospital, Hyderabad (Deccan), we treated from 400 to 500 cases (including indoor and outdoor patients) annually, and about 80 cases of tropical hepatic abscess, many of these latter being cases that had never attended the hospital for

dysentery. It is a disease of adults, being rare in children and old people. It occurs all over India, but especially along the valleys of our great rivers and in the deltas and other low-lying parts. It is initially caused by a special amœboid organism (*Entamœba histolytica*), the effects of which are probably aggravated by the normal germs of the bowels taking on virulent properties.

Symptoms.—The symptoms are at first acute, then subacute and chronic, with great tendency to relapse. There are the usual dysentery symptoms, pain in abdomen, frequent passage of blood and mucus with griping and straining. There is seldom any fever. There is frequently a preliminary diarrhœa for a few days, the usual dysentery symptoms, then the stools contain mucus and blood, the latter being as a rule in streaks. The stools may number from 16 to 20 or even 60 in the 24 hours. In from four days to a week the stools consist of a thin red fluid containing blood, mucus, pus, and often shreddy material. It is often followed by inflammation or abscess of the liver, or lasting ulceration of the large bowel. Then the disease gradually disappears, the patient convalesces and gets well, or there may be relapses. Abscess of the liver may develop after some weeks or even months, especially if relapses have occurred. If the symptoms become more severe, extensive destruction of the bowel occurs, there is much straining, more frequent calls to stool, sloughs are passed, the stools are putrid, constitutional symptoms are very intense the pulse is frequent and small, there is great prostration and the "typhoid state" sets in. Occasionally the patient rallies from this condition, even when seemingly *in extermis*. The acute or subacute form may pass into the chronic, and this may last for years, with rallies and relapses, the patient becoming greatly emaciated.

Amœbic dysentery is recognised by its chronic course and irregularity—the great tendency to implicate the liver, the relapses after periods of cessation, the fluid stools, the presence of the *Entamœba histolytica* in the stools, and its direct or indirect fatality. In general terms it may be said that in this form the mucous and submucous coats become affected with an inflammatory infiltration which tends to break down and form ulcers. The liver is large and congested and in a certain percentage of cases tropical abscess of the liver occurs. In chronic cases there is a tendency to localised hardening and contraction of the bowel. The essential cause of the disease is the Entamœba histolytica (often associated with other amœbæ) which is easily recognised in the fresh stools under the microscope as a large amœboid organism which is greenish in colour, has a comparatively small eccentrically placed nucleus and a vacuolated body.

Preventive.—The preventive measures are the same as for bacillary dysentery.

Common Round Worm—Ascaris Lumbricoides.

These parasites are very similar in general appearance to the common earthworm. The male is about 4 to 6 inches and the female 10 to 12 inches long. The *Ascaris lumbricoides* is a smooth fairly cylindrical worm, tapering at both ends, transparent, yellowish-red in colour, with fine circular lines on its surface. The anterior end has a mouth divided into three lobes or papillæ, two below and one above. The tail is bluntly curved in the male and has a double spicule near the end. The eggs are about $\frac{1}{500}$ inch in diameter, have a hard shell and are coated with an uneven, mulberry like albuminous envelope. This worm occurs in man and in a large number of animals, such as the dog, pig, etc. An intermediate host is not required. The parasite lives in the lower part of the small intestine and in the uppermost part of the large bowel. They are often discharged with fæces and sometimes vomited.

In warm moist earth, in about a month, the embryo develops to form a coiled up worm-like structure within the shell. Further development does not take place until it reaches the alimentary tract, when the embryo is hatched out. Man

is infected mainly through polluted water, soiled vgetables, fruits, and soiled hands. The worm matures and begins to discharge eggs in about a month from the time the egg is ingested.

FIG. 84 —*a*, natural size ; *b*, head, magnified ; *c*, ovum, magnified. Ascaris lumbricoides (V. JAKSCH).

As a rule it is only when the worm is present in large numbers that it produces any serious disturbance, such as appendicitis, congestion of the bowels, jaundice, liver abscess, etc.

Symptoms.—There are no definite symptoms, but there may be capricious appetite, colicky pains, indigestion, peevishness or irritability and sometimes loss of flesh. One is personally convinced that a form of fever occasionally arises in Native soldiers from their presence. It is a safe rule to treat an undefined type of fever attributable to no cause with Santonin. The examination of the stool for the eggs indicates whether these worms are present. Round worms are very prevalent and are often multiple. One has expelled as many as 47 from a Gurkha rifleman recently and counted as many as 63 from one person in the course of a year. They have been found in the peritoneal cavity, in the common bile duct and they often find their way to the stomach whence they are vomited. One is of opinion that a large number of the cases of undefined fever met with in natives in this country is attributable to some form of toxin produced by round worms which is absorbed into the system. The symptoms are very much like those of ordinary simple continued fever. If the cause is not discovered and the patient treated, irregular outbursts of this fever occur periodically. The frequency with which a dose of Santonin (5 grains) and castor oil removes this fever permanently and expels round worms has led one to believe that this is more than a coincidence. In all cases of undefined fever, which are known to be neither malarial nor typhoid, and the ova of round worms are found in the stools, one invariably gives santonin and castor oil, and in a certain proportion of the cases this treatment brings the fever to a close.

Round worms are far the commonest intestinal parasites of this country. Every native of the poorer, and a large percentage of the better, classes, is infected at one period or another with these parasites. The extent of their prevalence is

well known to all physicians of our large Indian hospitals. One is confident that these worms are responsible for considerably more mischief and disease in the Native Army than is generally recognised.

Prevention.—The chief preventive measures are the use of wholesome water for drinking purposes, thorough cooking of all food, cleaning of hands before eating, and incineration of all excreta containing the eggs of round worms.

Chief Diseases of the Liver met with in Troops.

Situation of the liver.—The liver is the largest gland in the body, weighing from 50 to 60 ounces, and is situated on the right side and middle line of the abdomen high up, its upper surface fitting into what is known as the right dome of the diaphragm. It consists of five lobes, the *right* which is the largest, *left* which extends across the middle line for a few inches, and three small lobes. On the surface of the body the position of the liver corresponds to the area extending from about an inch below the right nipple line to the line of the margin of the ribs. Backwards it extends throughout the depth of the chest. The liver in Europeans in India, as in all tropical countries, is very liable to disturbance of function, to congestion, and even inflammation. This arises from various causes, amongst which the high atmospheric temperature stimulates and then lowers its functional activities, more work is thrown upon it as the lungs do less (pp. 18, 19); there is impairment from the defective diet; errors in eating and drinking are not withstood as in a temperate climate; and, lastly, malaria and dysentery impair its functions.

Tropical Liver.

Synonyms.—Indian Liver; Hyperæmia or Congestion of the Liver.

Tropical liver consists of congestion resulting from the combined conditions associated with the life of the European in the tropics. The congestion is usually active, and when it occurs in the newly arrived, it is usually acute. In old residents it comes on more gradually and lasts longer. There is a painful enlargement of the liver, fever and some constitutional disturbance, with an absence of indications of any other disease. It may arise from indiscretions in eating, excesses in alcohol, chills or undue exposure to the sun. The condition begins with a feeling of malaise, loss of appetite, nausea, unpleasant taste in the mouth and headache. There is usually some indigestion, a coated tongue and either constipation or diarrhœa, the motions being pale in colour; a sense of weight in the right side of the abdomen high up, and the liver is enlarged, painful and tender; there is also pain in the right shoulder and about the right shoulder blade. The urine is scanty, high-coloured, and has a red sediment on standing. There is often some irritability of temper. There is with these conditions slight rise of temperature, seldom over 100° F. The disease lasts usually about three days. It frequently recurs after longer or shorter intervals.

Prevention.—When the condition becomes chronic there should be a complete change of habits that give rise to it. The patient should be placed on a non-stimulating spare diet, and given a course of natural mineral waters or Carlsbad salts. All stimulants and rich food, especially beef and mutton, should be eschewed; plain, wholesome, easily assimilated food—fish, fowl, abundance of well-cooked vegetables,

and ripe fruit. Active regular exercise is one of the great safeguards against tropical liver. Chills are to be avoided and the clothing worn should be suitable to the weather. Night is the time when these chills chiefly occur. A cholera belt and a light flannel pyjama suit should be worn at this time. All heavy wines—port, sherry, madeira, marsala, etc.—and beer of all kinds, should be rigidly avoided. If an alcoholic beverage is considered necessary the best is well diluted Scotch whisky, or some light claret, taken with meals in strict moderation.

The chief cause are excess in eating and drinking, rich and highly seasoned food, alcoholic habits, sedentary life and lethargy, superabundance of sleep, sudden stoppage of chronic discharges, as the bleeding from internal piles ; malarial paroxysms ; sudden meteorological changes, especially when operating in conjunction with one or more of the foregoing causes, dysenteric attacks, and sudden stoppage of free perspiration.

Inflammation of the Liver or Hepatitis.

Symptoms.—Sometimes during an attack of congestion the patient suffers from a shivering fit, severe headache, fever, frequent pulse, pain over the liver, especially over the arch of the right ribs, increased by pressure, coughing or deep breathing, and lying on the left side, much tenderness over the liver, pain in the right shoulder, foul breath, coated tongue, high-coloured urine, constipation with light coloured stools or diarrhœa with bilious stools ; much depression and loss of appetite. The liver is slightly but uniformly enlarged, there may be slight jaundice, nausea or vomiting and slight fever. It will be seen that the symptoms are those of congestion of the liver in an aggravated form, the congestion often leading to it. It is often associated with dysentery. The first attacks often proceed no further, and after a purgative, a few days' rest in bed and light diet, the patient is all right again.

Prevention.—The means of prevention are the same as those for congestion of the liver.

Tropical Liver Abscess.

Synonym.—Amœbic Abscess of the Liver.

In this disease there are one or more abscesses in the substance of the liver which are often associated with a history of preceding dysentery of the amœbic kind. It occurs all over India, but especially in the Deccan, Bombay, Madras, in the United Provinces, Lower Bengal and the Delta of the Ganges. Tropical abscess of the liver arises from an inflammation of that organ which goes on to form pus, the usual cause being the access to the liver of the *Entamœba histolytica* from the intestines. The predisposing causes are the occurrence of amœbic dysentery, which is said to be present in the vast majority of cases ; it is especially met with in people from 30 to 50 years of age.

Abscess of the liver caused 100 admissions with 34 deaths in 1909, 115 admissions with 55 deaths amongst our European troops in 1908, and 165 with 70 deaths in 1907.

Cases occur amongst Europeans frequently, and in these the connection with dysentery is not always clear, and is by some authorities attributed to over-eating, over-drinking, and preceding damage to the structure of the liver brought on by malaria, and the effects of residence in a tropical climate. Nevertheless tropical abscess of the liver is in the vast majority of cases met with in India, associated with dysentery. It is a curious fact that although children get dysentery frequently the disease in them is not followed by hepatic abscess, whilst 95 per cent. of the cases occur in the male sex. Abscess of the liver occurs at all seasons of the year. The special cause of the disease is said to be the *Entamœba histolytica*, either alone or with vegetable microbes. The action of these amœba is intensified by the co-existence of bacilli or micrococci; it is the same organism as is met with in the large bowel in amœbic dysentery. When several abscesses exist there is usually some form of bacteria present in the pus with the amœbæ. Such mixed infection may account for the different types of symptoms met with in cases of liver abscess. The infection occurs from the bowel through the portal system (p. 145). Later in the disease the pus of liver abscess may be quite sterile.

Symptoms.—There are the symptoms of congestion of the liver with lassitude, gradual loss of appetite, periodical fever in the afternoon or evening, preceded by shivering fits. In acute cases the temperature may be high, associated with repeated rigors and followed by profuse perspiration, and pain and discomfort in the right side. The treatment for congestion or inflammation does not relieve—the shivering, fever and sweats continue, usually daily, and slight jaundice may occur. The temperature rises to 100° or 102°F. There is at this stage usually general discomfort or pain and tenderness in the region of the liver, which radiates to the right shoulder. The liver is enlarged, especially in an upward direction, but if the abscess projects below the margin of the ribs, a fluctuating swelling may generally be felt. There is usually either nausea or actual vomiting, especially during the attacks of fever. There may be a bulging in the right side; the skin over some part of the liver now has a glistening appearance, and this part may "pit" when pressed by the finger. In some cases fluctuation may be felt. The emaciation progresses, a peculiar sallowness appears; the patient has now a worn and haggard expression. The shivering fits, fever and sweat continue daily, the pain is less marked, but when the abscess is near the surface it may become acute again. The patient never lies on the left side, he is always on his back with the lower limbs flexed, and he prefers the chest raised. There is always an increase in the white blood corpuscles, affecting the polymorphonuclear cells; this may be considerable.

The temperature may be remittent or intermittent, or normal or subnormal all along. There may be no great enlargement of the liver. The abscess may tend towards the lungs, stomach, duodenum, small intestines, colon, pleural cavity (especially the right), peritoneal cavity, into any of which it may burst. The patient's chances are better when the abscess bursts into the right lung or bowel than in any other situation, otherwise his best chance is secured by early diagnosis and an early operation to let out all the accumulated pus. If left alone the abscess may point through the abdominal wall near the pit of the stomach, or may burst into the general peritoneal cavity. In some cases it becomes encysted. The abscesses vary in size from containing an ounce or so to several pints of pus. The abscess is, as a rule, single, although there may be two or more, and it usually occupies the posterior part of the right lobe, and is lobulated. It contains peculiar thick reddish-brown or thin anchovy paste-like pus, which has a disagreeable sweetish smell. When left to itself the abscess most usually bursts into the right lung. In duration liver abscess varies from two to four weeks to several months. The writer has seen a case that was tapped 49 times over a period of seven months, with ultimate cure without opening; and another in which a European was sent home with a liver abscess which was not operated on at the time, but had to be opened at once on his return to India, eight months later.

There may be an absence of symptoms until the abscess bursts into the lungs and the patient coughs up some of the anchovy paste-like pus. It may be easy or difficult to diagnose. In India we always think of it as a possibility in all cases of undefined fever. Large abscesses may occur without any signs or symptoms of

the disease. On one occasion one saw an officer die from the sudden rupture of an abscess into the lungs while playing polo. In Hyderabad (Deccan) we frequently held *post-mortems* on cases dying of other diseases, when abscesses existed without any obvious signs or symptoms, and others in which the pus had dried up into putty-like pus. The abscess is as a rule near the surface of the liver. Abscesses most frequently occur in the right lobe and in 70 per cent. of the cases it is the right lobe alone which is involved ; in half the cases the abscess is solitary.

Entamœba histolytica occurs in the pus of 10 per cent. It is usually found only in the walls. When the abscess tends towards the lung this amœba is found in the phlegm coughed up. They are seldom found in the pus when this is first evacuated, but appear in the subsequent discharge several days after opening the abscess. If there is infection of the liver both by the Entamœba histolytica and various bacilli of micrococci, one or several abscesses may form rapidly, and then rapid blood poisoning ensues, with an early fatal issue before the abscess has had time to approach the surface or any internal organ. In multiple abscesses of purely amœbic origin, the symptoms are less general. The mortality of the disease in India taking all cases is between 60 and 70 per cent.

Prevention.—Avoidance of excess of eating and drinking, rich food, curries, condiments, and alcohol. A sufficient amount of excercise should be taken daily. Cold baths are to be avoided and either tepid or warm ones used instead. The early cure of all cases of dysentery is an important factor in the prevention of tropical abscess of the liver.

The preventive measures mentioned under *Tropical Liver* apply also to some extent to the prevention of tropical abscess of the liver.

Venereal Diseases.

Widespread error as to the nature of venereal disease.—No case of recent venereal infection in an active or manifest stage should be permitted to proceed on field service. Most cases of venereal that occur on field service are relapses of a secondary character. There are exceptions to this, as that of the Chitral Relief Force, when it was considered that a large proportion of the primary syphilitic and gonorrhœa cases were acquired at Nowshera and Hoti Mardan *en route* to the front. The prevention of fresh cases of venereal disease on the march to the front and on field service is chiefly disciplinary. In connection with the subject of venereal diseases in the Army, one would ask you to forgive a momentary diversion from the subject in hand. On three occasions in my own experience during the last few years in one way or another the question of venereal disease in our Army cropped up in conversation with officers of average intelligence, and one was surprised at the little that is known about this class of diseases and the attitude maintained against the victims. The general notion that prevailed appeared to be that once a man had the misfortune to acquire venereal disease of any kind (except gonorrhœa) he is necessarily *hors de combat* ever after, that he can never become an efficient soldier again, and that as a non-commissioned officer he has undergone such a moral degradation in the eyes of his comrades that he is unfit to command his section.

Venereal disease has decreased in both Native and European troops in recent years, but the decrease in Native troops has not been nearly so marked as in European troops.

Years.	Venereal Diseases admission rate per 1,000.	
	Native Troops.	European Troops.
1903	24·5	274·0
1904	20·6	198·5
1905	19 6	153·7
1906	16·2	117·3
1907	14·7	89·9
1908	15·2	69·6
1909	16·4	67·8

The total admissions in European troops in 1908 with a strength of 68,933 were 4,801, in Native troops with a strength of 126,975 were 1,934.

The decline of syphilis and venereal disease generally is chiefly due to widespread temperance, and to modern methods of restoring efficiency by treatment.

Varieties of venereal disease.—All forms of venereal disease are due to infection by specific microbes that are communicated by persons already suffering from the disease. In general terms venereal diseases include three distinct affections—(1) *gonorrhœa ;* (2) *soft chancre*, or ulcer of the penis ; and (3) *hard chancre*, with its probable sequels.

1. **Gonorrhœa**.—*Gonorrhœa* is a specific local disease, the main indication of which is a discharge of pus from the penis caused by a distinct microbe (gonococcus) invading the cells of the mucous membrane of that canal. It is characterised by pain and burning urination and has often a protracted course. If neglected it may give rise to a form of inflammation of one testicle, of the bladder and other complications. When not neglected it as a rule remains a local malady. It sometimes gives rise to a suppurating bubo in one or both groins. In the absence of personal cleanliness while the attack is on, a very acute form of inflammation of the eye may occur, due to contact of the membrane covering the eye becoming infected with the pus from the urethra, and this may end in destruction of vision of the affected eye. In very exceptional cases the germ gains access to the circulation, generalises and may effect joints, possibly the heart, eye, brain or other organs. In all one's experience with troops one has only seen two such cases—such complications are therefore very rare. In the Army in India the ordinary case of gonorrhœa is curable in about a month,

after which it does not affect the man's future as an efficient soldier. Recurrent gonorrhœa may in from 10 to 20 years develop what we call an organic stricture, with its possible train of complications, but very rarely occurs while the soldier is a fighting man. The use of the towel or handkerchiefs of a person suffering from the disease may lead to the severe disease of the eye just mentioned.

The disease usually comes on about the fourth day after sexual intercourse with an infected woman, the signs of the disease comes on rapidly and the most careful precautions such as washing and disinfection, and injecting caustic solution or permanganate of potassium solution immediately after acquiring the infection, often fails to prevent it.

2. **Soft chancre.**—*Soft chancre* is a purely local malady in the form of an ulcer on the penis, caused by a specific bacillus infecting the penis, and in many cases the lymphatic glands in the groin, giving rise to a suppurating bubo; there its effects cease. The virulence of the local infection may, in exceptional cases, cause widespread destruction of the part originally attacked. These cases also get perfectly well and their misfortune does not militate against their efficiency as soldiers. Soft chancre comes on in a few days after sexual intercourse with an infected woman and the most careful precautions, including washing and disinfection immediately after intercourse, often fails to prevent it.

3. **Hard chancre.**—The third variety of venereal disease is what in its initial stage is known as *hard chancre*, which usually leads to the general constitutional condition known as *secondary*, and sometimes to *tertiary*, *syphilis*. Syphilis is a chronic infectious disease, characterised by various lesions of which the initial one is chancre (a specific ulcer on the penis). The disease is in the vast majority of cases acquired by sexual intercourse, the chancre appearing in from two to three weeks. Soon after the chancre appears the glands in both groins become enlarged and hard. Later on other lymphatic glands enlarge, ulcers occur in the mouth and throat, eruptions appear on the skin, the eye may become inflamed, and there is much constitutional disturbance. This is the form of venereal disease which is such a prevalent cause of inefficiency and invaliding in the Army. In it the essential cause is an excessively minute worm-like spiral animal parasite (*Spirochæte pallida*) which has recently been successfully inoculated into anthropoid apes, and it is possible that we are within a measurable time of acquiring further information on the subject which may ultimately be utilised in the practical treatment of these cases. The poison of true syphilis is slow in attacking the constitution, is very lasting in its effects, and its treatment to be complete has to be carried on for at least two years. Whilst this is the only form of really serious venereal disease, one would emphasise that it is not necessarily a cause of either prolonged inefficiency or excessive invaliding—it is only in exceptional cases that

the disease runs on uncontrolled by treatment, in which case invaliding becomes inevitable. The experience of the last six or eight years indicates that the majority of these cases are absolutely amenable to curative treatment and the men rendered thoroughly efficient. With the experience of several Gurkha regiments in one's mind, and the recorded evidence of many R. A. M. C. officers, one has no hesitation in repeating that in the vast majority of cases, specific syphilis may be cured, and in some the disease apparently completely eradicated.

Systematic specific treatment required to restore efficiency of cases of syphilis.—One of the most comprehensve, complete, and fertile sources of restoring efficiency in such cases in recent times is the order directing that they should be treated specifically, systematically, and for at least one year, after which they should be watched. Certain definite methods of treatment are advocated (but not enjoined), which, though they may not meet with universal approval, are, under the circumstances of service in an Army in India, undoubtedly the best. One refers specially to the intramuscular use of mercury.

When thoroughly and persistently treated the third stage of syphilis may not develop; but if not so treated the disease affects the entire system. Syphilis is in the vast majority of cases acquired by sexual intercourse with a woman suffering from the disease, but it may be acquired by a healthy man sharing the pipe of an infected comrade.

The third stage usually takes many years to develop and is now rarely seen in the Army, chiefly on account of the persistent treatment based on sound principles carried out.

One cannot insist too much on the principle of keeping these cases under observation and treatment without being actually in hospital. After disappearance of the primary and early secondary manifestations of the disease in these cases, the patient need not necessarily be kept in hospital. His attendance once a week is all that is required, and eventually less frequently. In this the co-operation of commandant, adjutant, and medical officer is essential. One knows of numerous cases of Gurkhas in various regiments who have been through this course of treatment carried out in its integrity, and are now cured and as fit as any of their comrades. Apart from his physical sufferings, a man who has the misfortune to acquire true syphilis goes through much mental torture. It is undesirable in the interests of the service to treat these men as if they were criminals, and every effort should be made to cause them to understand that with a proper course of treatment the disease will be cured, and their efficiency as soldiers not affected. To the medical officer, of course, the case of venereal in a patient requires the same care, attention and consideration as any other sick person under his treatment.

Our experience in regard to the effects of *salvarsan* (a preparation of arsenic, a solution of which is injected either into the veins or

under the skin) in the cure of syphilis is as yet insufficient to justify our expressing a definite opinion as to its merits, but so far as it goes seems to indicate that in certain cases it rapidly brings about a cure.

A certain limited number of cases of venereal disease is acquired in European troops by contagion from latrine seats from discharge left on the seats by infected men. This can, of course, only occur in the active stage of the disease, and no man with venereal in this stage should be at duty. In the hospital there should be special seats for venereal cases. It can to some extent be avoided by covering the seats with a disinfectant.

Prevention.—Strict cleanliness after impure sexual connection may to some extent prevent venereal, and the addition of a disinfectant to the water for washing may be useful.

Considering the slowness of the infection in true syphilis it is possible that thorough washing of the external genitals after sexual intercourse and strict attention to cleanliness subsequently, has some influence in preventing infection, although these measures can in no sense be relied on and often fail. A solution of lysoform (1 per cent.) has been recommended for cleansing.

It has recently been stated on authority that an ointment consisting of one part of calomel and two parts of lanolin has proved a preventive if rubbed into the male external genital (penis) within 20 minutes after exposure to infection. This is stated to have been proved by external inoculation of syphilitic virus and the subsequent use of the ointment.

"In the Austro-Hungarian Army, by an order published in May 1907, men are encouraged, but not compelled, to use a 1 in 1,000 solution of corrosive sublimate for ablution, and a 3 per cent. solution of albargin for urethral injections. In the neighbourhood of the entrance to barracks a room is provided with the necessary equipment, solutions, etc., and the men are instructed in the advantage of their use. A register is kept, and the men enter their names, with the day and hour of using the preventives. In every case of venereal disease a note is made whether the man has used the preventives or not. In some garrisons this system is said to have effected a decrease of 62 per cent. in the cases of venereal disease."*

These are all, however, only attempts to evade the penalties for immoral conduct. Chastity, morality, healthy living, and a due comprehension of the terrible nature of at least one class of venereal disease, are the real precautions. Officers and non-commissioned officers should explain to the men the nature and consequences of venereal disease. The fact that the syphilitic transmits the disease to his children, should he marry, is a matter for grave consideration, and if properly explained to soldiers may help to bring home to them the risks they run

* Colonel R. H. Firth, *Military Hygiene*, p. 40.

in promiscuous intercourse with impure women. The real method of prevention is complete abstention of sexual intercourse with women leading an immoral life. Men should avoid the possibility of acquiring venereal. No person who risks contagion is ever safe. The risk is always great, and the consequences may completely wreck a man's career, make a permanent crock of him, apart from the fact that he may hand down to posterity a family of syphilitic children. Continent men are, as a rule, better soldiers than the strongest men who cannot control their sexual passions. Sexual intercourse is not necessary to the health of the soldier, and in no way aids in the maintenance of good health. It is not in any sense essential. The youths, who form a large part of our Army in India, are certainly not improved by it, and would be healthier and stronger men without it.

Alcoholism and venereal disease often go hand in hand. Alcohol is responsible for a vast amount of disease in the Army, either directly or indirectly. Under its influence men expose themselves to causes of disease which they would not think of doing in their more rational moments.

All persons suffering from venereal disease must report sick at once. For this not only expedites the cure of the disease but removes a source of danger to their healthy comrades. When men suffering from venereal disease do not report sick, they should be punished.

SAND-FLY FEVER.*

The term "sand-flies" is somewhat elastically employed, and in India it is popularly used to include two distinct families of flies, *viz.*, *Simulidæ* or true sand-flies, and *Psychodidæ* or owl midges. Both families are Diptera or two-winged insects, and as in all such, the metamorphosis is complete, passing through the stages of—egg, larva, pupa and fully formed insect or imago.

The true sand-flies are also called black-flies, buffalo-gnats, midges, *pipsa* (Sik.) and *potu* (Hind.). Of these there is only one genus—Simulium—of which there are about 70 species known. They are met with specially in the tropics, but occur in the Arctic regions, and in certain temperate and sub-tropical zones are pestilential. The genus Simulium is universally distributed in India and in some districts certain species occur in myriads. They are all small dark-coloured, greyish or black flies, but sometimes they have a yellowish base to the abdomen. They are stoutly built and humpbacked; the head is small, the wings are relatively large and delicate and in most species iridescent, the antennæ are short, straight, destitute of hairs and consist of eleven segments. The palpi have four segments, the fourth being marked

* This account of "sand-fly" fever and "sand-flies" should have followed that of MALARIAL FEVERS OF INDIA.

by rings, the male palpi are larger than the female. The proboscis is short, stout and inconspicuous, but decidedly serviceable. The legs are stout and compressed. The species of Simulium are known by the first, second and third veins on the wings being dark and the other veins being pale. The males in many species have silvery markings on the thorax and are ash-coloured; the females are mostly black. All species of Simulium are most restless, and even when stationary are perpetually moving their legs about as if they were feelers. They are naturally highly gregarious and are often seen in countless swarms above damp places, the drying ground of rice and sugarcane fields, and the damp around wash-houses and wells, are favourite haunts. The females are exceedingly greedy blood-suckers. Their bite is severe, and produces considerable discomfort in most people, and much irritation in lower animals. The males do not bite. The male flies often occur in dancing swarms above moist ground. The preliminary stages of the life history of true sand-flies are passed in water.

The family Psychodidæ or owl midges includes the extensive genus of *Phlebotomus*, the species of which genus in India occur in considerably greater numbers than those of *Simulium* or true sand-flies. It is to the various species of *Phlebotomus* that the term "sand-flies" is popularly applied. The species of *Phlebotomus* are small, midge-like, fluffy-looking, yellowish brown insects, recognised by their extremely hairy bodies, wings, and antennæ, and their general moth-like appearance. The wings are relatively broad and spread out or diverge from the body, pointing upwards and backwards; the body is slender, the legs long, the proboscis elongated, horny and prominent, and projects vertically beneath the head. The females of some species are vicious biters and voracious blood-suckers. They are readily seen after feeding on man or lower animals as the abdomen is then distended with blood. They can be recognised as a genus by the naked eye and with an entomological hand-lens, most species can be differentiated. The sexes are readily distinguished by the large and complex clasping apparatus at the end of the last abdominal segment of the male, the female abdomen being without this structure. They are weak fliers and breed close to where they are found. The males do not bite. The genus *Phlebotomus* occurs widely distributed over India and species may be taken in practically every district; they have been found in several hill stations, including Murree, Mussoorie and Chakrata, at over 7,000 feet. There are six or seven species of *Phlebotomus* known in India; two are very generally distributed, the others are more or less scattered. The life history of the various species of Phlebotomus is only imperfectly known, but the preliminary stages of most species so far investigated are passed in water, in mud, cesspool or other liquid filth. The length of the life-history of different species varies from a month in the hot weather to six or eight weeks in the winter (in Lower Bengal). The *eggs* are usually single or in small clusters, on either water or in wet and dirty places, and usually hatch in about six days on an average taken from several species.

"Sand-fly," Phlebotomus or pappateci fever is an acute specific fever characterised by definite symptoms and due to the bite of one or more species of Phlebotomus (insects popularly called "sand-flies" in India), the insect having previously bitten a person suffering from the early stage of this fever.

So far only one species, called *Phlebotomus papatasii*, has been incriminated as a carrier of Phlebotomus fever. Regarding the habits, mode of life and breeding, and method of hibernating (if any) of this particular species, we know practically nothing. Several experts, including professional entomologists, who have worked at the subject, confess that they have not been able to ascertain where and how it breeds. During the day it may be found in bath-rooms, usually on the walls, in wash-houses, in dark corners of rooms near the floor, on clothing, under piles of damp bricks or stones, in any damp and shady place at hand, and in latrines; they like whitewashed walls and avoid those that are painted or distempered. They are often found behind verandah shutters, and in a few instances they have been found in barrack rooms. The *eggs* of *P. papatasii* have not been found in nature, and on only a few occasions have its larvæ been found in the natural state—in cracks in walls. Adults have been found in several stations in India on the plains and in two instances on the hills at a height of over 7,000 feet. It is extremely difficult to follow out the life-history of the *P. papatasii* as it is an exceedingly delicate fly and soon dies in cages—no one has so far succeeded in breeding the insect from its eggs. We do not as yet know whether this is the species that carries "sand-fly" fever in India, and it is possible that other species of Phlebotomus, and even species of Simulium, may do so. In Dalmatia and Herzogovina, in the Adriatic littoral, in Crete and Malta, it is the only species that has been proved to be a carrier of Phlebotomus fever, although there are at least two other species on the Adriatic coast and several species in Crete and Malta, all of which have been investigated with negative results as regards their capacity to carry the fever virus from man to man. There are a large number of species of Phlebotomus known (over 100), but so far no systematic account of the Indian species has been published, although there are excellens descriptions of a few Indian species on record. The general characters of the genus Phlebotomus are dealt with above, and as stated the shape and venation of the wing is a means of distinguishing most species of Phlebotomus. In *P. papatasii* the wing is more pointed than in other species, and the posterior border of the wing is more arched than the anterior.

Symptoms of "sand-fly" fever.—The symptoms of Phlebotomus fever are fairly well defined. It begins suddenly with chilliness, nausea or actual vomiting, severe frontal headache, pains in the back and sleeplessness. The pulse, considering that the patient has fever, is slow, (70—80 per minute), there is marked redness of the eyes (the disease is called "pink eye" in Crete) which are heavy but do not

water, the face is flushed and the temperature varies from 100° to 103° Fahr. The tongue is covered with a thin white coat and there may be diarrhœa. The slowness of the pulse is characteristic—it does not increase in rapidity with the rise of temperature as it does with practically all other fevers, and the flushed face and red eyes give the patient a dissipated appearance. There are likewise stiffness and pain in the back and pain in the calves of the legs which are peculiar to this fever. In about 30 per cent of the cases the fever lasts three days, but in a small proportion of cases it may go on for seven or eight days. Second attacks sometimes occur even in the same season. The period of incubation, that is, the length of time which elapses from the time of being bitten by an infected Phlebotomus and the commencement of the symptoms, varies from about 3½ to 7 days. It is never fatal and it leaves no sting or after effects, but in some cases the patient is left in a wretchedly weakened condition and convalescence may be slow. No known remedy cuts short the fever ; aspirin or salicylate of soda are most frequently given to lessen the pains in the back and legs and to keep down the temperature. So far no parasites or micro-organisms of any kind have been discovered in man, although they probably exist in the blood in an ultra-microscopical form and will some day be discovered, which is also the case in dengue, typhus fever, small-pox, seven-day fever, and yellow fever. Nor has any specific micro-organism been so far found in the infected *P. papatasii*. A healthy man bitten by an infected Phlebotomus gets the fever on or about the seventh day after the bite and his blood remains infective for only two days after the fever begins. When the blood of an infected person taken during the first or second day of the fever is injected into a healthy person, the period of incubation is usually shorter than after the natural mode of infection.

The disease is prevalent in certain districts of the Punjab, especially Peshawar and Nowshera ; it occurs almost epidemically in some parts of Central India, and is met with in Manipur, Assam, and probably also in Dehra Dun. A severe and widespread form of the disease occurs in Chitral. I have recently been told that in a station on the North-Western Frontier "75 out of 400 odd men of one British regiment suffered from it this summer, and in a letter on the subject just received it is stated that "it has caused more sickness than anything else in this (First) Division." It is highly probable that Phlebotomus fever is much more widespread in India than has hitherto been supposed. Reports of outbreaks of it are being constantly published, but they are all silent on the subjects regarding which some practically useful information is urgently required—the breeding places of the infecting species of Phlebotomus, and the best measures for attempting to exterminate them. It is very probable that in the endemic centres of the disease some of the cases recorded as influenza, seven-day fever, fever of unknown origin, and under other headings, are instances of Phlebotomus fever.

Prevention of bites.—The best applications to ward off the attacks of both Simulium and Phlebotomus flies are: Eucalyptus or deodar oil, lanolin, oil of lemon grass, and kerosine oil. The parts of the body attacked are chiefly the ankles, face, neck and hands—they have a special *penchant* for the ankles, probably because more exposed and vulnerable. We can usually see them when attacking the face and hands. The proboscis can readily penetrate thin socks; they cannot get through a double pair of thin socks or a single pair of thick ones. The ankles are safe when boots and not shoes are worn.

The adult flies inside houses and barracks may be killed by one of several fumigant insecticides. One of the best consists of the fumes given off by igniting equal parts of saponified cresol and camphor (four ounces of each to every 1,000 cubic feet of air space), closing all doors and windows, etc., as in ordinary disinfecting fumigation, while this is being done. These fumes leave no unpleasantness in the room and kill all insects harboured. Formaldehyde gas and sulphur dioxide are also efficacious as fumigants. It is said that the smoke caused by placing live coals on cow-dung prevents the approach of sand-flies in camps. Vacation of houses and barracks infested with infected Phlebotomus is a method that has been successfully tried in Chitral, but is, of course, a measure of limited applicability. A sand-fly net around the bed is advisable; the fabric of the net should be such as to have a fine mesh, not less than 24 strands to the inch. It is, of course, close inside such a net within doors at night in the hot weather, but would be tolerable outside. All the foregoing remarks apply to all species called "sand-flies." As patients suffering from Phlebotomus fever are infective for a period of 48 hours, they should certainly be isolated for the first two days, and from dusk until morning of these two days kept under a close-meshed net. The disease can only arise from Phlebotomus flies biting an infected person during the first two days of the fever, and then (at the end of the seventh day) biting healthy persons.

Prevention of breeding.—In view of what is known regarding the breeding of several species of Simulium and Phlebotomus, especially as to their larval life, the indications to effect a reduction in their number at present are—to prevent the formation of puddles and damp places around houses and barracks; to convey all refuse water from houses, barracks, wash-houses, swimming baths, kitchens, wells, etc., away in *pukka* drains, avoid the use of absorption pits, and to do away with collections of surface water.

ITCH OR SCABIES.

Itch or scabies is a contagious animal-parasitic disease due to a small turtle-shaped parasite, the itch-mite (*Acarus scabiei*), which burrows and forms little channels beneath the skin and causes much irritation. The disease is characterised

by a multiform eruption of papules, vesicles and pustules, of peculiar distribution attended by intense itching. The character of the eruption is often much modified by scratching. The parasite is about 100th of an inch long, with four pairs of legs. It is the female that causes the local irritation. She is twice the size of the male. The female lives in burrows of the skin, the male wanders over the surface. The male is only very rarely found on the skin, and apparently takes no part in the production of the symptoms. Each burrow forms a small whitish or white and black line, and contains one female who lives there for a few months, laying eggs as she advances. The young ones hatch out in less than a week. The female in burrowing causes considerable

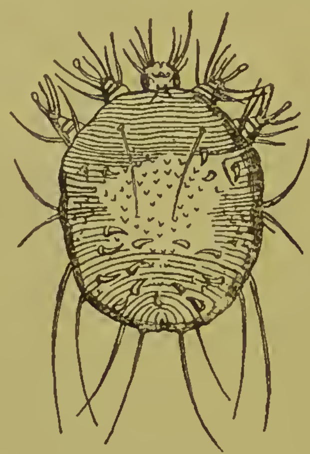

Fig. 85.—Human itch-mite (after Leuckart).

itching and the consequent scratching brings about inflammation. The thin skin of the different regions of the body is chiefly attacked first, such as the webs of the fingers, the wrist, toes and feet, abdomen, external genitals, armpits, inside of the thighs, and finally it may extend to all parts of the body except the head and the face.

Tho amount of irritation of the skin caused varies in different people; in those with very delicate skins the type of the eruption is usually much more inflammatory. In predisposed persons signs of eczema may arise and then in addition to the usual and characteristic lesions of scabies, those of eczema are added. In cases lasting any length of time, the burrows and other consequent lesions may be hidden by the inflammation of the eczema and so the real nature of the disease obscured. Burrows (cuniculi) are tortuous, straight, zigzag, dotted, slightly elevated dark-gray or blackish lines varying from $\frac{1}{8}$ to $\frac{1}{2}$ an inch in length. They are formed by the impregnated female which penetrates the cuticle obliquely into the deeper layers of the scarf skin (p. 352), depositing as it goes along 8 to 15 eggs, forming a minute burrow or passage. The burrows are not numerous as the irritation caused by the penetration of the parasites leads to violent scratching and their destruction, or gives rise to the formation of vesicles and pustules, and consequently their formation is prevented.

The special diagnostic features of scabies are —its peculiar distribution, multiple character of the eruption, progressive development and usually a history of contagion. Eczema is usually limited in extent or irregularly distributed, distinctly patchy, with often the formation of large diffused areas; it is variable in its clinical behaviour, better and worse from time to time, and differs, moreover, in the absence of burrows and of a history of contagion.

Itch is readily cured, and as soon as the parasites and their eggs are destroyed, the itching and the secondary symptoms, as a rule, rapidly disappear. The course of the untreated disease is chronic and progressive, showing no tendency to spontaneous disappearance.

The treatment is entirely external and consists of a preliminary soap and hot water bath, an application twice daily, for three days, of any remedy that is destructive to the itch-mites and their eggs; and finally another bath. The usual application employed is sulphur ointment or sulphur and lime lotion. The latter is cleaner and cheaper.

The disease is contagious to a marked degree. It is very widespread in this country, and is, for apparent reasons, chiefly met with in men of unclean habits, and is contracted by the intimate association of those suffering from the disease with the healthy. It is, however, occasionally met with among those who are quite clean in their habits.

In the aggregate there are a large number of admissions for itch in the Army in India, practically every Native regiment has some cases every year. It is sometimes epidemic, especially amongst newly-joined Native recruits and young soldiers; it is common amongst the children in Native married lines.

Prevention.—Itch may be prevented by cleanliness of the body, by means of a daily bath with soap, use of clean clothes, and avoidance of contact with persons suffering from the disease. The bedding and kit of all men with the disease should be sent to the hospital to be disinfected.

PRICKLY HEAT.

This is an inflammation of the sweat glands of the skin, possibly associated with excessive secretion of the sebaceous glands (p. 353), usually occurring in Europeans during the hot weather and rainy season, and is due to blocking up of the sweat follicles. After much scratching there is a general crop of small red pointed papules, which are very close together, or actually run into one another, forming large red patches all over the body, especially in the abdomen, back, chest and arms. It is very annoying from the tingling and uncontrollable desire to scratch the parts affected. The scratching often leads to other affections of the skin, such as boils, eczema, etc. The predisposing causes are—exercise (which makes the surface warm and excites perspiration), hot drinks and wearing flannel.

Treatment.—A good application is—

Thymol	$\frac{1}{2}$ drachm.
Glycerine of borax	2 ounces.
Water	18 ,,

To be applied.

Avoid flannel next the skin, violent exercise, ice drinks, hot baths and the use of irritating soaps. When there is much itching add a few ounces of washing soda to the bath. An unpleasant remedy is the application of fresh cocoanut oil, or a mixture of 8 parts of almond oil to one of lanolin. Applications of sal volatile or the addition of Scrubb's ammonia to the bath water sometimes relieves, rubbing afterwards with a rough towel. The addition of a small quantity (an ounce or so) of izal, cyllin, lysol, creolin, or phenyl to the bath may also relieve. Saturated solution of boracic acid, or a weak carbolic lotion (1 to 100) may be applied over the irritable area. It is advisable to use light clothing and an abstemious diet.

"DHOBIE ITCH."

"Dhobie itch" is the general term applied to a form of body ringworm that is usually met with in the crutch, external genital organs, buttocks, upper and inner parts of the thighs, and in the armpits. It is exceedingly common in India, few people escaping it at one time or another. It is due to a skin parasite, which is a fungus and very similar to that found in the scattered forms of body ringworm. In the early stage the fungus is abundant in the eruption, but scanty in old patches. There are several species of this fungus. This disease is acquired—by actual contact with those suffering from it, from infected clothes, and possibly also by bathing in stagnant waters containing the germs of the disease.

"Dhobie itch" is considered to be often acquired through the infection of clothing during washing. Many cases of eczema, and other skin diseases, including more than one form of ringworm, are in India called by this name. Dhobies often wash clothes in the dirty water of tanks or ponds which contain the germs of skin diseases, etc., or they dry the clothes on the ground (which also contains disease-germs), instead of suspending them from clothes lines to dry.

Symptoms.—It begins as a circular or oval slightly raised red scaly patch which spreads at the margins, and, as a rule, from local infection several such patches are spreading and coalescing simultaneously, until an area of from half to one square foot of surface may be involved. It is very itchy, especially when the body is hot and sweating, or after getting into bed at night. The constant scratching often sets up eczema or other secondary infective diseases of the skin.

Prevention.—Body cleanliness, frequent bathing in water known to be clean, frequent change of under-clothes and the use of a non-irritating soap in the regions chiefly affected by this disease. The manner in which *dhobies* carry out the washing of clothes in cantonments requires much supervision. The best general remedy is the liniment of iodine applied with a camel hair brush, a few applications the first day and one daily for two days subsequently. Then wait a few days to see if any uncured spots remain. Another excellent remedy is chrysophanic acid (the active principle of Goa powder) made up as follows :—Chroysophanic acid 30 grains, oil of cloves 10 drops, and vaseline 1 ounce. Chrysarobin may be used in place of the chrysophanic acid. The great disadvantages of these latter applications are that they often set up a considerable amount of inflammation, and stain clothes.

Body Ringworm.

Ringworm is a contagious, vegetable parasitic disease, due to the invasion of the cutaneous structures by a species of fungus. The clinical characters of ringworm vary according to the part affected. Ringworm of the general surface appears as one or more small slightly elevated, sharply limited, somewhat scaly reddish spots, with sometimes minute papules, vesico-papules, or vesicles, especially at the circumference. The patch spreads in a uniform manner at the margins, is slightly scaly, and tends to clear in the centre, assuming a ring-like appearance. When coming under observation, the patches are usually from one half to one inch in diameter: in the European the central portion is pale or pale red, and the outer part more or less elevated and somewhat congested and scaly. One or several patches are present. After reaching a certain size they may remain stationary, or in exceptional cases, may tend to spontaneous disappearance. At times when close together, several may merge and form a large, irregular, gyrate patch. Itching, usually slight, may or may not be present. The inner portion of the upper part of the thighs and scrotum may be attacked, and here the affection, favoured by heat and moisture, develops rapidly and may soon lose its ordinary appearances, the inflammatory symptoms becoming especially prominent. The whole of this region may become involved (we then have the same condition as "dhobie itch") presenting all the symptoms of eczema; the border, however, is sharply defined, and usually one or more outlying patches of the ordinary type of the disease may be seen. Everything the diseased area touches is contagious—clothes, bedding, floor mats, etc., unless these are thoroughly disinfected and exposed to the sun.

Prevention.—The preventive measures are practically the same as for itch.

Abscess.

Abscesses are collections of "matter" or pus in some tissue or organ of the body, and may be acute or chronic. We shall here refer

only to those that are of rapid formation. An acute abscess is a circumscribed abnormal cavity containing pus, which pus is confined by a wall of diseased tissue. An abscess may be superficial or deep, and may be any size. A superficial abscess lies in the skin and subcutaneous cellular tissue. A deep abscess forms near the muscles. An abscess may burst spontaneously, or may have to be opened by a lancet. Abscesses and boils are caused by micrococci usually of the kind called *staphylococci* (p. 407), but severe acute abscesses may arise from local infection by *streptococci* (p. 407). These usually gain access to the skin through some small, often invisible, abrasion, cut or scratch, grow and multiply in the tissue below the skin, and give rise to the formation of yellow pus. Superficial abscesses are amongst the most frequent forms of minor complaints met with in regimental hospitals.

Signs and symptoms.—Abscesses are always preceded by inflammation; there is pain, heat, redness and swelling in the affected part. The pain is usually of a throbbing character; the swelling is hard, "pits" on pressure, and when pus is formed a soft part may be felt in the middle of the hardness. If there is much pus, fluctuation may be felt by pressing on one part of the abscess with one forefinger, while the other forefinger is kept steady on another part, the pressure causing the pus to bulge against the stationary finger.

Prevention.—Abscesses are prevented by cleanliness of body and clothes, avoidance of scratches, abrasions and local injuries, and early attention to such injuries when they do occur.

Boils or Furunculi.

A boil is a localised inflammation beginning in a hair follicle and resulting in the production of a small slough. It is usually caused by staphylococci. A small, hard, red pimple begins around a hair follicle, increases in size and is painful and tender. At the centre a whitish spot appears, and soon the boil bursts and discharges pus and a small slough, which relieves the pain. The nearest chain of lymphatic glands are often enlarged and painful, but do not form pus.

Prevention.—Cleanliness of body and clothes, avoidance of all causes giving rise to skin eruptions and irritation of the skin which lead to scratching (see *Prickly Heat*, "*Dhobie Itch*," *Ringworm*, *Abscess*) and abstemiousness in animal food, especially during the hot weather, are the chief preventive measures.

Injuries Producing Internal Derangements of Joints.

This class of injury includes displacement of cartilages within joints, inclusion of fringes of the covering of the joint between joint surfaces and the locking of joints due to loose bodies. The history in all these cases is much the same. There is sudden acute pain accompanied by inability to move the joint, which in the lower

extremity usually results in throwing the patient to the ground. This is followed by effusion of fluid into the joint. If seen immediately it will be found that the movements are limited, any attempt to bring about the full range of movement being accompanied by great pain. These accidents are far more common in the knee than in any other joint.

The first thing to do is to disengage the displaced cartilage, or other body from between the articular cartilages. In the case of the knee this is done by slowly and steadily flexing the joint as far as possible, and then suddenly extending it. Patients in whom this accident often happens can usually rectify matters for themselves by bending the leg upon the thigh and then suddenly kicking. After the replacement the joint should be kept at rest upon a pillow for two or three days, according to the severity of the synovitis which results. After that time, massage should be employed. The loose body or displaced cartilage will probably require removal later.

One has introduced a mention of the above condition here because of the fact that since football and hockey have become established games in the service, one has met a not inconsiderable number of cases among our troops, whilst there are few regiments in which one or more European officers do not suffer, or have not suffered from some form of internal derangement of joints due to the causes enumerated.

There is no known way of preventing these accidents in those who play the games mentioned.

Sprains or strains of joints.—A sprain is the straining, tearing, or considerable stretching of the ligaments, capsule, and sometimes also of the tendons around a joint by some sudden twist or wrench. There is, as a rule, some laceration of the smaller blood-vessels, and sometimes also of the synovial membrane itself. In sprains of the wrist or ankle there may be displacement of one or more of the tendons around the joint. The accident is often followed by an effusion of fluid into the joint and tendon sheaths, and bleeding into the subcutaneous tissues. They are usually caused by falls, twists, or wrenches of the joints, or blows, or some sudden unnatural movement of the part. The diagnosis of a sprain rests upon the absence of either a dislocation or a fracture, and the history of the injury. Sprains are often more painful, severe, and serious accidents than either dislocations or fractures. The more serious forms of this injury, if not properly treated in the early stage, may cripple the joint affected permanently,

Signs.—Pain, and swelling at the seat of injury followed by increased heat, and subsequently by discoloration of the skin which becomes "black and blue."

Treatment.—Put the joint at complete rest on a pillow. If the sprain is in a joint of the upper extremity apply a padded splint to the inside of the limb and then place the forearm on a large arm-sling; if in a joint of the lower extremity place the patient in bed, apply a padded back splint to the limb and keep it slightly elevated. After the limb has been put to rest apply bandages dipped in cold water or an ice bag to the injured joint; if the pain is severe and cold applications cannot be tolerated, bathe the part with water as hot as can be borne comfortably, or apply hot bran or linseed poultices to it. If the pain is continuous and severe relief may be obtained by the application of a hot fomentation changed every two hours.

When the swelling is decreasing some stimulating liniment (the best being opodeldoc or soap liniment) should be rubbed over the joint, and from this time onwards the joint should be carefully exercised. Avoid prolonged rest of the part, for this is frequently followed by permanent stiffness of the joint. Massage of the joint and the muscles around it should be begun in two or three days—daily massage for ten minutes at first, but gradually increased up to half an hour - together with movements of joint, both active and passive are required. This will expedite absorption of any effusion present, prevent pain and stiffness, and maintain the nutrition of the muscles.

Strains or sprains form one of the commonest forms of local injuries sustained by soldiers in the Army in India and little can be done to prevent them.

Frost-bite.

Force to be prepared for frost-bite.—The possible factor of frost-bite should not be omitted in our preparations for a war on our Indian frontiers, where the temperature may run to many degrees below zero for months at a stretch. In the China-Japan War of 1894-95, frost-bite alone accounted for 4·2 per cent. of sickness, but during the late war, only 0·35 per cent., and this under much more severe conditions; the Japanese with their former experience were fully prepared for the ravages of a Manchurian winter in 1904-05.

Dry and still air at very low temperatures may be borne without injury, whereas the effects of air in motion at low temperature is very penetrating, and the same is the case with very cold damp air. The duration of exposure, the extent of body-surface exposed, the state of general health and condition of physiological resistance, in other words, the degree of fitness, determine the extent to which a man is affected by cold.

Nature and degrees of frost-bite.—*Frost-bite* varies extremely in its severity from a temporary local bloodlessness to complete gangrene of the part affected, and is the result of exposure of a part to great cold. The parts most liable to frost-bite are the toes, feet, fingers, hands, nose and ears, all because of their position, which involves special exposure, and a blood-supply readily affected by external influences. On field service frost-bite is specially liable to affect those in a weakly state from previous ill-health, or those who are run down from the general hardships of a winter campaign.

The general effects vary with the intensity of the cold, degree of protection of the part, the general state of the man's health and other conditions. Tissues may be frozen to insensibility and yet recover perfectly, but if kept frozen, death of the affected part follows. If the part be frozen until it is absolutely dead, subsequent thawing will not be followed by the re-entry of blood, and the part will gradually undergo the changes characteristic of gangrene. If actual death of the part has not occurred, the blood re-enters, and an inflammation, at first quite aseptic, ensues, a free exudation of serum rapidly takes place, the part swells and shows all the signs of impaired circulation, vesicles with red or purple contents rise, and finally, if the part be seriously damaged, circulation completely ceases and moist gangrene is established—either limited and superficial, or involving a considerable part of a limb. In these cases the inflammation usually becomes septic on account of the growth of microbes from the skin into the damaged structures, and much tissue is often thus destroyed.

Signs of frost-bite.—The first sign is redness of the part associated with some pain; this is, as a rule, rapidly followed by purplish discolouration and lessened sensibility. Next congelation arises, the part becomes white, hard and quite insensitive. Then the freezing extends

deeper until the parts are frozen to death. Signs of returning circulation, however slow, are the first signs of recovery. Swelling and often blistering follow. Persistent pallor or a red or purple colour, which is not removed by pressure, is a sign of ill-omen.

Treatment of frost-bite.—These cases have to be treated with much judgment and patience, as safe progress is always slow. The temperature of the part has to be very slowly raised, the limb elevated and gently rubbed with snow, or bathed with cold water. Next friction with an oiled hand is adopted, and finally the part is wrapped in cotton-wool, the rubbing being continued.

Prevention of frost-bite.—When proper precautions are adopted, intense cold is better borne by our British troops than is tropical heat. With intense cold microbic life and the active causes of infective disease, are practically absent. It is stated that "Spitzbergen, in summer, is the most healthy spot on earth."

Clothing.—The most important factor in protecting from cold is suitable clothing. The underwear, specially that next the skin, should be of good flannel. For this the loosely woven Jaegar wool is incomparably superior to other stuffs. The cholera belt round the abdomen is very comforting. Too much care cannot be given to the feet, which are the parts first attacked by frost-bite. Stout worsted socks, ammunition boots, putties, and with "shorts" half hose round the knees, should be worn. Serge "shorts" are preferable to drill if there is risk of frost-bite. The outer clothing should be khaki serge, plus the "coat warm British," the latter being always made loose so as not to interfere with the circulation or muscular action. A thick woollen sweater is, of course, always provided as well as a balaclava cap and woollen mittens. When actually in camp nothing can compare with Gilgit boots for comfort. The clothing provided for our troops in Thibet was probably one of the best outfits that any army operating in intense cold has been supplied with (p. 67).

"One of the best arrangements for the avoidance of this accident consists in the use of heavy, soft, woollen stockings, over which, together with the trousers, what are known as German socks, heavy and reaching up to the knees, are drawn. The foot should then be encased in loose moccasins and Arctic overshoes put on over the whole." (MUNSON.)

Food.—Next to clothing, the food-supply is of the utmost importance. Deficiency in quality and quantity of food is sure to reduce the strength of the men, favour the effects of cold and invite disease, especially if combined with dampness, impure air, defective personal and camp cleanliness, and want of exercise. FRANKLIN, speaking of food and clothing as supplementing each other during Polar cold, says: "During the whole of our march we experienced that no quantity of clothing could keep us warm while we fasted, but on those occasions when we were able to go to bed with full stomachs we passed the night

in a warm and comfortable manner." Ross wrote: "He who is well fed resists cold better than the man who is stinted, while starvation from cold follows but too soon on starvation in food. In every expedition or voyage to a Polar region the quantity of food should be increased, be that as inconvenient as it may. It would be desirable that men could acquire the taste for Greenland food, while all experience has shown that the large use of oil and fat meats is the true secret of life in these frozen regions."

Most suitable food-stuffs.—The best foods for cold climates are those concentrated forms which are readily and easily transformed into heat, and these are the kinds which are provided by Nature in the abundant animal life to be found along the Arctic littoral. Fats are specially yearned for and taken in large quantities, Northern explorers soon acquiring the habit of the natives in this respect. KANE says: "Our journeys have taught us the wisdom of the Esquimaux appetite, and there are few among us who do not relish a slice of raw blubber or a chunk of frozen walrus beef. The liver of a walrus eaten with little slices of his fat, of a verity is a delicious morsel" Fresh meat should be issued as liberally as practicable. It keeps well in a germless atmosphere. From all that has been stated, it will be evident that in campaigns in intensely cold countries the usual dietaries of field service should be modified, and this point should receive deliberate attention before the Army takes the field.

Japanese method of preventing frost-bite.—Before the occurrence of the severe Manchurian winter cold, instructions were issued regarding the hygienic conditions in winter, the means of protection against frost-bite, and the rendering of first aid in cases of frost-bite, and each man received an ointment of some sort to use to prevent or treat frost-bite. We see that the Japanese showed everywhere a care, down to the smallest details, for the health of the individual soldier, thereby securing the efficiency of their army as a fighting force.

TETANUS.

Tetanus from wounds on field service.—Tetanus in former years or pre-antiseptic days was a much-dreaded complication of gun-shot and other wounds on field service. The possibility of its occurrence in wounds that have become accidentally inoculated with the tetanus bacillus from the clothes, earth, or dirt, before medical officers have had the opportunity of seeing these cases, should never be lost sight of. The bacillus is in the form of thin rods, many of which have a sort of knob at one end (hence the name "drum-stick" bacillus), this knob indicating the position of the spores of the germ. One would avail oneself of this opportunity of recommending that every field hospital be provided with a supply of anti-tetanus serum, and that it be used prophylactically in all cases likely to be followed by this complication. As a prophylactic it, in the vast majority of cases, prevents tetanus

if given sufficiently early—that is, within the first two or three, and even up to five, days of the wound; and as a curative, when tetanus has developed, its use gives the patient the best chance of recovery. For the last 20 years one has adopted a definite line of prevention in all wounds likely to be followed by tetanus. The focus of possible infection should be attacked at once and if possible rendered sterile. In the case of the finger, toe, or foot the surgeon may consider it necessary to amputate the diseased part, and subsequently apply pure carbolic acid followed by a gauze kept saturated with peroxide of hydrogen which is inimical to the tetanus bacillus.

Prevention.—All wounds no matter how trifling or superficial, or extensive, should be treated antiseptically from the beginning. I personally invariably apply pure liquid carbolic acid to every wound in soldiers as soon as they come under observation. In some cases this delays healing for a few days, but it certainly prevents tetanus and all forms of septic infection.

Snake-bite.

On certain Frontiers—Burma, Assam, Bhutan, Manipur, etc.—it is well to be prepared to meet cases of poisonous snake-bite, and on expeditions to these and other snake-infested places, it is desirable that every unit should be provided with a few doses of what is known as polyvalent anti-venemous serum, which protects from either colubrine or viperine snakes, of which the cobra and Russell's viper (*daboia*) and the common krait (*Bungarus candidus*) are respectively the species usually met with. Personally, when going through the annual first aid lessons, one always incidentally mentions the best impromptu methods of dealing with snake-bite. In poisonous snake regions it is specially necessary that the men should not move about after dark without boots and putties, particularly where there is much jungle. All standing camps should have low scrub and jungle cleared all round for a distance of about 100 yards, the cut vegetation being collected to leeward and burnt when dry. The hospitals of units should always be provided with permanganate of potassium crystals.

PART V.

MEDICAL STATISTICS IN INDIAN FRONTIER WARFARE.

Collection of medical statistics on field service.—One of the most important points connected with the administrative charge of the Principal Medical Officer with a force is the collection of accurate and reliable statistics regarding the sick and wounded, those dying from disease and from injuries inflicted by the enemy, and those killed while in action. No medical officer should grudge the time devoted to the furnishing such information from the records of his unit or hospital, as they are indispensably necessary. It is from these, and the reports accompanying them, that the medical history of the campaign is formulated, and the causes of sickness and mortality worked out. It is from the carefully compiled records of the Principal Medical Officer of the force, together with such observations as he has made, and the inferences to be deduced from them, that the medical lessons of each campaign are to be learnt. These final reports should be a guide to all future campaigns in the geographical region to which they refer, or in similar regions. Therefore in this respect the responsibility of administrative medical officers is considerable, and all his subordinate officers should loyally share it by cheerfully rendering all possible aid. Commanding Officers lend their aid in this by forwarding the strength of their units at the prescribed times, and furnishing such other information as may be asked for. The medical statistics of the British Army, both in peace and war, are probably the most reliable of any large mass of figures dealing with disease and mortality, and we pride ourselves as military medical officers on their accuracy.

The group of statistics at the end of the campaign, the reports of—medical officers of field ambulances and general hospitals, administrative medical officers of divisions, those of sanitary officers, and the personal observations made by the Principal Medical Officer of the entire force, form the basis of the medical history of the campaign.

Uniform nomenclature for all Armies desirable.—In all such reports a uniform system of classification of diseases and wounds is necessary; and for this the *Nomenclature of Diseases of the Royal College of Pysicians*, London, 1906, is adhered to. It is necessary also that the statistics are compiled on a uniform basis, and that they are absolutely reliable for purposes of comparing one campaign with another. In consequence of a want of uniformity in the classification and nomenclature of diseases and injuries incidental to peace and war in

different nations, it has not always been possible to compare the sickness and mortality of different armies. With the object of establishing a definite, fixed, and comparable nomenclature and classification of diseases, injuries and wounds, a Committee on International Military Medical Statistics met at Buda-Pesth in 1894. That Committee formulated a scheme, which, if followed, would remove many of the difficulties medical statisticians of Armies have hitherto contended with. Carried out in its integrity, this scheme would create a basis for comparison and yield a large amount of valuable information not otherwise get-at-able.

The medical statistics of a campaign show the degree of healthiness or unhealthiness that prevailed in the campaign as a whole, and in different places and periods of the campaign. They point out at a glance what parts were most unhealthy, and as far as possible explain the cause of such unhealthiness, and the measures adopted to reduce it. They show us to what extent epidemic and infectious general diseases prevailed, the conditions under which they occurred, and the mortality and inefficiency caused thereby. They likewise give us the actual numbers of deaths from all causes and individual causes, with the mortality-rate to strength, and the causes of these deaths; the relative amount of sickness to strength as a whole, and at different periods. All these and various other points of considerable interest to the military sanitary officer are brought out by medical statistics of campaigns.

The morning state.—The special items of information which the G. O. C. of the force, division, or brigade requires are—the actual number of sick and wounded, the number of men rendered inefficient, the nature, extent, and probable causes of any prevalent diseases, in general terms what is being done for them, and what steps are taken to remove the causes and lessen these diseases in the force. Part of this is furnished in the morning state, which also gives the number remaining in hospital, fresh admissions, discharges, number transferred towards the base, and the number of deaths. All medical officers submit this return regarding their charges. The medical officer will recollect that in invested or besieged garrisons, men convalescing or suffering from minor complaints may be fit for various garrison duties, although not able to march. A special return is required for all officers and men who have sustained injuries in action. This must be carefully prepared and in such cases the medical officer gives a concise and accurate description of the kind of wound, its degree of severity, the phraseology of the regulations being strictly adhered to; strict attention to this would obviate much unnecessary trouble to all concerned later on. A weekly return of sick and wounded is submitted from all hospitals in the field.

Collection of medical statistics in Japanese Army during war.—In the Japanese Army the Principal Medical Officer of the Field Forces, P. M. Os. of the different armies, lines of communication,

divisions and fortresses, officers commanding hospital units (with the exception of those of reserve hospitals), officers commanding bearer battalions, reserve medical personnel units, medical and surgical reserve depôts, sick and wounded transport department units, hospital trains and hospital ships, are obliged to keep field diaries. The P. M. O. of a depôt, division and of a reserve hospital keeps, instead, what is called a *depôt diary*. The professional records of the sick and wounded go with the patient wherever he goes, in the form of *case sheets*. During an action every wounded man, sent back from his unit, must have his wounds examined and recorded in the field hospitals. This is the commencement of the case sheet, and notes on the case are added during and throughout the whole of the patient's stay in any unit of the medical service. These sheets become very valuable documents for the preparation of the professional, medical and surgical histories of the war, as well as evidence in establishing the amount and nature of gratuity pension that is to be given for injuries. They also indicate whether the man has had adequate care and attention from the time of his falling ill, or being wounded. There is also a form for prescriptions which accompanies and is attached to the case sheets. The cases are divided into three classes—the first being those whose diseases and injuries were caused by duty; second, not so caused, but caused by circumstances over which the patient had no control; the third caused by the patient's own neglect. In battalion units there is also a classification into—1st, those who must be admitted into the battalion sick reserve while the battalion is in a stationary camp (cantoned), or must be carried on wagons, or on horseback during a march; 2nd, those excused duty but who come up daily for treatment in cantonments, or have their rifles and valises carried for them on the march; and 3rd, those who have "medicine and duty" marked on their sick reports, and who are relieved of their valises during a march, but not allowed to march out of the ranks. If any man of the last class reports sick three days running, he must be transferred to either the first or second class. Admission and discharge books are kept for various units, showing the different classes of sick.

The medical organisation of the Japanese Army is based upon the field medical organisation of the German Army, but the Japanese have modified and simplified the German system to suit their own ideas, and in mobility their equipment of mobile units corresponds more with ours than with that of the German Army.

The whole medical organisation proved very elastic during the war, the *personnel* took every advantage of local resources, and showed great skill in improvising equipment. The large mass of casualties was dealt with rapidly and without confusion from beginning to end. This was achieved not only by a logical organisation and sufficiency of *personnel* for all purposes, but also by an intelligent and harmonious co-operation of compulsory and voluntary reserves from Civil and Red Cross Societies under the direction and absolute control of the regular Army Medical Service.

PART VI.

THE SANITARY SERVICE IN INDIAN FRONTIER WARFARE.

PERSONNEL.

Medical personnel.—You may not be familiar with the distribution of the different parts of the medical *personnel* in our campaigns, and it may be advisable here to roughly sketch the ordinary arrangements, showing the share of duties taken by medical officers of all ranks. One would premise by stating that from the experience of previous expeditions and all our recent manœuvres on a large scale, these arrangements are subject to modifications and some elasticity, and the following has reference to a large force taking the field on one of our Frontiers.*

Principal Medical Officer, H. M. F., India.—The Principal Medical Officer, H. M. Forces in India at Army Head-quarters, is the responsible adviser of the Commander-in-Chief in India on all subjects dealing with the health of the Army in India. On the outbreak of a war, he may be expected to give his opinion on all matters connected with the country to be invaded—its climate and productions; the rations, cltohing, shelter required, sanitary arrangements and organisation for the prevention of disease amongst the troops. He arranges all matters relating to medical and surgical stores, supplies, equipment, ambulance and medical services to accompany the Army, and nominates the *personnel* to the different administrative posts and hospitals. He issues to the Principal Medical Officer of the Force such special instructions for guidance in all matters connected with the above as he considers necessary to meet the conditions of the particular campaign entered upon.

Administrative Medical Service of Field Force.—The Principal Medical Officer of the Force or Forces is the responsible advising Staff Officer of the General Officer Commanding the Force or Forces, in connection with all matters affecting the health and medical arrangements of the force. He is responsible for the entire arrangements for the prevention of sickness, the removal of the wounded from the field, and the general care and treatment of all sick and wounded throughout the force. Under the G. O. C. he has supreme control over the Medical Service connected with the field force. He ordinarily remains at the head-quarters of the field force. He is in communication with the heads of all departments of supply, transport, equipment,

* In the preparation of this Section one is indebted to an *Essay on Medical Arrangements in War* by Lieut.-Col. C. W S. MAGRATH, R.A.M.C., published in the November 1906 issue of the *Journal of the Royal Army Medical Corps*; and to the *Field Service Manual, Medical*, 1908, and *Field Service Regulations*, 1908.

stores, etc., and keeps them informed of what is necessary in connection with the Medical Service.

The P. M. O. Force or Forces advises the G. O. C. of the Force or Forces on all questions relating to rations, clothing, shelter, sanitary arrangements, precautions for preventing disease, and on all other questions having reference to the physical efficiency and health of the force. On being informed of the presence of any unusual disease, he immediately investigates the cause of the same, ascertains whether it proceeds from, or is aggravated by, defects in cleansing, drainage nuisances, overcrowding, defective ventilation, bad or deficient water-supply, dampness, marshy ground, or any other local cause; or from bad or deficient food, intemperance, unwholesome liquor, fruit, defective clothing or shelter, exposure, fatigue, or from any other cause. He reports to the Quartermaster-General on such causes, and the measures for their removal, and furnishes the G. O. C. with a daily report on the progress or decline of the disease. He accompanies the Quartermaster-General (or an officer he appoints) on the line of march, and collects information regarding the medical topography, especially as regards sites to be occupied or avoided. He submits to the P. M. O., H. M. F. in India, a weekly report on all subjects connected with the hygiene and sanitary state of the Army in the field. He advises on the sanitary arrangements of the camps and of occupied towns and villages, and reports whether the surface and vicinity of camps, towns, etc., are kept clean; whether drainage of surface is properly arranged for; that the dead are being properly interred; whether carcases are properly buried or disposed of; and whether the water-supply is kept pure. He reports to the Quartermaster-General or Camp Staff Officer or Provost Marshal of the camp concerned, sanitary defects he may find, and if such defects are general, to the Quartermaster-General or the G. O. C. the Force.

Inspections, P. M. O. Forces.—The P. M. O. Forces periodically inspects the Medical Service connected with the field force, assures himself that everything connected with it is in an efficient condition and according to Regulations. He distributes the medical establishment and equipment as may be considered necessary for carrying out the instructions contained in the Regulations. He assures himself that the sick of corps unfit for duty are sent to the field ambulances with the force, and do not encumber the fighting force; that the field ambulances with the fighting line are not overcrowded, and that the sick and wounded are sent to the base. He gives the G. O. C. Forces a numerical return by corps showing the number of sick and wounded sent to the base, and reports to the P. M. O., H. M. Forces in India, the hygienic state of the Army in the field, and to the same officer, submits copies of all sanitary recommendations made to the G. O. C. as well as a weekly telegraphic summary of all sick and wounded. If there is no P. M. O., lines of communication, he holds administrative medical control of these also.

Before an engagement he arranges in consultation with the G. O. C. the places for the dressing stations of the bearer companies and for pitching field ambulances and satisfies himself that all arrangements are being made for dressing the wounded in the quickest and most effective way.

The P. M. O. Field Force informs the P. M. O. lines of communication as to the number of patients to be transferred towards the base from time to time, so as to enable him to arrange for their care and treatment *en route* to the base. The P. M. O. lines of communication should at all times know the available accommodation in all hospitals under his control, and whenever possible give medical officers in charge of hospitals timely intimation as to the day and probable hours of arrival of convoys of sick and wounded at different stations. This is urgently necessary. He details the staff attached to the hospitals on the lines of communication, the necessary establishment for convoys of sick and wounded proceeding towards the base of operations, and sees that sufficient medicines, appliances, and medical comforts have been provided for the road.

Sanitary Medical Service in the field.—During our three largest concentration of troops in recent times (Delhi 1902-03, Rawalpindi 1905 and Agra 1907), there was a special sanitary staff attached to the forces, consisting of a chief sanitary officer, under the P. M. O. of the Force, and a divisional sanitary officer, under the P. M. O. Division (these latter P. M. O.'s were not always appointed); and in future campaigns a similar sanitary staff will be appointed.

When a chief sanitary officer is appointed with the force, he will, under the P. M. O. Force, carry out all the sanitary duties of that officer, to whom he is responsible that such duties are efficiently discharged. As these duties are specially concerned with the prevention of disease and inefficiency in the force, they will be referred to later on under the heading of *Duties of Sanitary Officers*.

Principal Medical Officer of Divisions.—A P. M. O. is appointed to each infantry and each cavalry division. He is on the divisional staff, and is responsible for all sanitary and medical service in his division. He ensures absence of damming back of the sick on the fighting line, keeps the P. M. O. Field Force and P. M. O. lines of communication constantly informed of the number of sick and wounded requiring conveyance towards the base, and the form of transport needed.

Principal Medical Officer, Lines of Communication.—A P.M.O. is posted to the staff of the G. O. C. lines of communication, and under the latter officer he controls all medical arrangements from and including the base, up to the field ambulances with the fighting force, and he

frequently inspects these. He is responsible for the transport of medical and surgical stores and *personnel* to the front. He arranges, under the G. O. C. lines of communication, for the conveyance of all sick and wounded from the front and lines of communication to the base.

Administrative and Executive Sanitary Staff in Indian Frontier Warfare.—In our Frontier campaigns of any size there will probably usually be a chief sanitary medical officer (under the P. M. O. of the whole force) with one staff sanitary medical officer to each division under him. The chief sanitary officer, with the approval of the P.M.O. of the Force, drafts a series of rules regarding the sanitation of camps, prevention of disease, and the method of dealing with infectious disease. These are added to as occasion requires.

The chief sanitary officer, as a matter of routine, will provide each divisional sanitary officer with all information reaching him likely to affect the health of the troops, and where practicable, at the opening of the campaign, will make a tour of inspection round all camps to ascertain that all sanitary orders are being systematically carried out.

Inspection of camps by Principal Medical Officer Forces, and Chief Sanitary Officer.—The Principal Medical Officer of the Force and the chief sanitary officer will make a general inspection of the camps as early as practicable. In this they will direct their attention to the general arrangement of the tents in camps, the water supplies, arrangements for bathing and washing of clothes, position of kitchens, the food-supply of troops, and arrangements for feeding; the position and construction of night-soil trenches or incinerators, arrangement for the accumulation and destruction of all camp refuse; standings of transport animals; disposition of field ambulances of divisional troops, and that these are in thorough working order. It cannot be expected, however, that these officers are able to attend to the details of all hygienic requirements necessary to safeguard the health of the troops They have already issued their orders on these points in a general way, the responsibility that these orders are duly observed in all camps, and that attention to the details embraced in those orders are given effect to, rests with divisional sanitary officers. It will often happen that the latter officer will have to act on his own initiative as regards the sanitary orders of his charge, in which case he apprizes the chief sanitary officer of the orders issued.

The chief sanitary officer will examine and report on the quality of the water-supply, point out the best sources of supply, and also indicate any precautions required for the collecting, storing, purifying and distributing water. He will note the nature of the rations, means of disposal of kitchen refuse (which should be removed to the

site chosen and never used as fuel for cooking). In camps moving daily the combustible refuse of kitchens may be heaped in a selected place and burnt. He should observe the position, construction, working and state of the *night-soil trenches* or incinerators, and of the surrounding area.

Divisional Sanitary Officer's duties—Initial inspection to be thorough.—The responsibility regarding the sanitary work of camps thus falls on the divisional sanitary officer, who keeps in constant touch with the divisional staff. The sanitary officer of a division is the responsible sanitary adviser of the divisional commander and P. M. O. Division. His special duties are to see that all orders issued by the chief sanitary officer are carried out, and in the absence of such orders, the duties of the latter as far as his division is concerned (under the principal medical officer, division,) devolves upon him. He must make a thorough initial inspection of every camp in his charge. During this inspection which may last two or more days, and in which he should if possible be attended by the camp staff officer or provost marshal, the medical officer and quarter-master of the unit, he directs special attention to the following in each camp:—The disposition of the tents, freedom of ventilation within and around them, number of occupants in each tent, order and neatness in the arrangement of kits, cleanliness of the tents, presence or absence of *débris* of food on the floors. He directs that no part of the daily food should be eaten in tents; the men should feed outside and not in the tents. They should eat their food in groups so as to accumulate *débris* and refuse, and thus facilitate clearing away. In inclement weather shelters for feeding in are desirable. He assures himself that all orders regarding the opening out and sunning of tents and their contents, and those about the drainage of the camp, are properly understood. He will have seen the general source or sources of *water-supply* (see p. 38 *et seq*.), issued, orders to safeguard it from all causes of contamination, investigated its quality, sufficiency, and means of distribution to all camps. In the camps of British troops he will inspect the water cisterns or casks, see that they are at a safe distance from latrines (especially night latrines, if these are in use), and standings of transport animals; observe the method of filtration or permanganating (if this is necessary), and assure himself that they are clean, that their disposition and the arrangements for keeping them full are satisfactory and with all troops that there is no possible form of pollution from the source to the consumer.

Finally, the inspection of the divisional sanitary officer should embrace a complete review of the sanitary arrangements of all the field ambulances attached to his division. He should minutely inquire into the manner in which it is proposed to deal with cases of enteric fever, dysentery and epidemic diarrhœa and other infectious diseases.*

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*Lieut.-Col. R. Caldwell, R.A.M.C., *Military Hygiene*, p. 322.

Further duties of Divisional Sanitary Officer.—As previously remarked, the initial inspection of the divisional sanitary officer should be thorough and complete, and notes should be made of such matters as require representation to the general officer commanding the division and chief sanitary officer. Any recommendations he makes should show thoughtfulness with regard to the special conditions in existence, the facility for carrying them out, the available sanitary establishment, and, in general, their reasonable practicability. Whenever he deems it necessary, he renews his visits, and, throughout the campaign, keeps a watchful eye on all conditions and causes liable to give rise to disease amongst the troops. All sanitary reports connected with unit camps should be submitted by the divisional sanitary officer, except where there is anything special to be represented by medical officers of units, in which case it is submitted through the usual channel.

The wide scope of the duties of the divisional sanitary officer should be recognised by military authority; all information called for by him provided, and all orders issued by him duly carried out. His specific duties are to prevent disease in the division. Preventive measures decrease the causes of disease on field service. Such causes in large bodies of troops on service are always in existence. In many cases the exercise of these functions requires much tact and firmness, but whenever any serious dereliction, slackness, or opposition is met with, it is to be instantly represented to the divisional commander. In this there can be no compromise.

A daily sanitary inspection of all camps indispensable.—Every camp with the force, however, must be subjected to a daily sanitary inspection by some responsible medical officer; this is indispensable. The basis of this is the inspection by the medical officers of individual regiments. Whenever possible one of the British officers of the corps should accompany him to take notes of, and see that any recommendations made are carried out, as this cannot with safety be delegated to subordinates. Medical officers of units should specially bear in mind that all the sanitary work of camps must be carried out daily in a routine way—they are responsible to their commanding officers that it is so.

Isolation and segregation camps.—With every division there should be provided an isolation and a segregation camp, the former for actual cases of infectious disease such as small-pox, measles, mumps, plague, cholera, etc., the latter for "contacts," that is, those who have lived in the same tents or hut as the patient. The tent previously occupied by the patient and "contacts" should be thoroughly fumigated and exposed to the sun for a few days before re-occupation. In practice it is desirable to transport condemned tents for both. A special site should be chosen for these camps as reasonably far from the main body

as military considerations permit. Officers commanding field ambulances should receive definite instructions as to what they are to do when any case of infectious disease comes to their hospitals, and they should be informed as to the precise position of the isolation and segregation camps. Where such camps cannot be established, it may be necessary to detach a section of the field ambulance to be used as an infectious diseases hospital, as was done by the Japanese in Manchuria.

Where epidemic infections disease of any kind is at all likely to happen, its invasion should be anticipated by the publication of rules regarding its prevention, and a sufficient number of appropriate portable disinfectant chambers might accompany the Army (their exact position being made known to all concerned) for disinfection of clothes, or improvised disinfectant chambers might be constructed—one per division.

On the outbreak of any infectious disease, definite orders should be at once published by the chief sanitary officer as to the steps to be taken to limit its spread, and effect its eradication. These orders will necessarily vary with the nature of the disease.

It stands to reason that military considerations must necessarily predominate under all circumstances connected with service in the field; hence under many conditions, several preventive measures may have to be either relinquished or temporarily suspended; this gives us solid grounds for endeavouring to make up for this temporary relaxation of such measures by rigid adherence to those preventive precepts that are not affected by military considerations.

No special sanitary officers with Japanese Army.—There were no special sanitary officers in the field with the Japanese armies in Manchuria, but the principal medical officer of divisions made use of one or other of his assistants for sanitary work, or selected one or more of the medical officers belonging to field hospitals who were specially fitted for sanitary work to carry out investigations of a sanitary nature. In the event of epidemics occurring, special sanitary committees were formed who were responsible for dealing with the epidemic, and special regulations were sent into the field to investigate scientifically the origin and nature of the epidemic.

Principles governing our Medical Service in Frontier Warfare.—The principles governing our orgnanisation of the Medical Service in the field in India are:—

(*a*) To provide for the immediate requirements of the force and to relieve it of non-effectives.

(*b*) To transfer the sick and wounded (trifling cases excepted) in the direction they most eventually go, namely, to the base of operations;

(*c*) To apportion the establishment and equipment to the requirements of the force as a whole.

Line of medical assistance from front to base.—The line of medical assistance from the Army in the field to the base is:—

1. Medical officers doing duty with corps and units.
2. Bearer Companies.
3. Field Hospitals.
4. Field Medical Store Depôts.
5. Sick-convoys and Hospital Trains.
6. Hospitals on the lines of communication.
7. General Hospital at the base of operations, or other suitable locality, and Military Base Depôts connected therewith.
8. Base Medical Store Depôts.*

In our territorial campaigns in India it would be rare to employ hospital ships; these need not therefore be referred to further.

Medical materiel and personnel of units.—With each corps unit there are :—

Materiél.—1 Pair field medical panniers.
1 Field medical companion.
1 Surgical haversack.
16 Blanket stretchers.
1 Field surgical cavalry bag for cavalry regiment and each battery of horse artillery.

Personnél.—1 Medical officer.
1 Assistant surgeon or hospital assistant.
1 Ward servant or ward orderly.

The equipment and medical resources in a regiment in the field are not intended to meet the requirements of cases of serious illness. Only comparatively trifling ailments, very temporary disturbances of health, and slight wounds, cases which will be fit to return to duty in a few days, can be adequately treated in the regimental hospital in the field.

Duties of medical officers of regiments or units.—The duties of the regimental medical officer in the field are always serious, and those connected with preventive measures are by far the most important. The foundation of the sanitary system in the field must be that of units. Infectious or epidemic disease appearing in one regiment may disseminate to the whole force. As now conducted on our large manœuvres, regimental sanitation is certainly on a much higher basis than it was twenty years ago. The far-reaching importance of regimental sanitation was fully recognised and acted up to by the Japanese,

* *Field Service Manual, Medical,* 1908.

who have an unprecedented record of comparative freedom from disease in the late war, under very adverse circumstances. One's personal experience is that we are still far from perfect in our regimental sanitation, and one of the chief causes is that the regimental officers do not take the interest in it which its importance demands. Commanding officers of regiments should be made entirely responsible for the health of their men, and the sanitary conditions under which they live on the march, during manœuvres, in barracks, and in the field, in the same way as officers commanding cavalry regiments are responsible for the state of their horses, the feeding, condition of stables, etc.

What at present happens is that a regimental medical officer is often new to the regiment, with British troops he must almost necessarily be so, unless by chance attached to it in some station previously. He is often young. He makes recommendations which the commanding officer may or may not carry out If not carried out the medical officer is placed in the unpleasant position of being obliged to represent the matter to higher authorities. A committee on the medical arrangements of the South African War stated: "No satisfactory system of camp sanitation can be carried out without the intelligent cooperation of company and commanding officers." The wording of this is unfortunate, as commanding officers do not co-operate with their junior regimental officers, but the principle that all officers should take part in the sanitary work of regiments is embraced in the above quotation. A commanding officer should have the whole responsibility placed on him as to the health of his corps and the sanitary state his corps lives in; if this is done, he will see that his sanitary staff, headed by the medical officer, do their duty, each company officer doing his share.

In organised schemes for the prevention of disease in regiments a great deal depends on the initiative, constant interest, practical knowledge and experience of the medical officers of regiments, and the recent orders regarding the instruction of junior medical officers of both services in large division cantonments is of the utmost importance in this respect.

We have already alluded *in extenso* to the duties of medical officers with units on the march to and at the front (pp. 69—71); and it is only necessary here to emphasise a few points referred to previously. The medical officer of units will be under the orders of the O. C. unit to which he is attached, but will receive instructions from, and be at the disposal of, the P. M. O.'s of the Division and Force. Medical officers of units advise their commanding officers on all matters relating to the health of the men. The chief duty of the military medical officer of regiments on service is the prevention rather than the cure of disease.

Weekly inspections of troops and followers.—After the troops and followers have left their respective stations, and during the whole

period they may be employed on active service, medical inspections will be made once a week, and in the event of the appearance of any infective disease, these inspections will be made daily when practicable, as it is very necessary that vigilant attention be given to the early detection of such disease.

When British soldiers report sick, they will be sent to the medical officer with the usual sick report in duplicate ; if they are passed on to a field ambulance one copy of the report will be sent with them, and the other, on which the man's disease and destination will be marked, returned to the officer commanding. Native officers and soldiers sent to field ambulances will be accompanied by the orthodox medical certificate prepared by the regimental medical officer.

Medical officers of regiments to keep an official diary.—Medical officers of units should keep a diary in which the disease and the method of disposal of men reporting sick, and all matters of medical interest is entered ; and they should be prepared to furnish any information connected with the sanitary and medical arrangement of their regiments when called upon to do so by the P. M. O. They afford such temporary assistance to sick and wounded as may be required in camp, on the line of march, and in action. They should specially avoid retaining with the regiment any man who requires hospital treatment, or who is really unfit for duty—such cases must be sent to the field ambulances. All temporary sick of regiments are detained in their section tents.

Senior medical officer of brigades.—The senior medical officer of a brigade is the adviser to the O. C. Brigade in all matters of a medical or sanitary character requiring prompt attention, and under the O. C. Brigade he is empowered to issue such medical and sanitary instructions as may be deemed necessary.

Personnel of units in Japanese Army.—In the Japanese Army the sanitation of a regimental camp is generally attended to by a battalion committee of which the senior medical officer is president. The other members are officers or non-commissioned officers from each of the companies. These committees, aided by the sanitary police of individual regiments, exercise strict supervision over all sanitary conditions likely to affect the health of the men. In each unit the medical staff is : To each infantry regiment (3 battalions), are attached 6 medical officers, 2 N.-C. O.'s and 12 men of the Army Medical Corps, and 48 bearers, the latter wear a red gauntlet instead of the Geneva cross ; to each cavalry regiment (3 squadrons), 2 medical officers, 1 N.-C. O. and 1 man of the Army Medical Corps ; to each artillery regiment (6 batteries), 3 medical officers and 3 men of the Army Medical Service. Each infantry battalion has 2 panniers containing medical and surgical material, and 12 stretchers. Two pack horses are allotted for the carriage of these articles.

Field ambulances in the field.—Field ambulances form the third line of medical assistance on field service, and are intended for the treatment of the sick and wounded of the force to which they are attached. They are equipped for 100 beds, divisible into 4 sections, each section being complete in itself. Attached to each field ambulance are 4 medical officers (the senior of whom is commanding officer), 8 assistant surgeons (British field ambulance) or 8 hospital assistants (Indian field ambulance).

The actual number of field ambulances to proceed with a force is fixed by the P. M. O., H. M. S Forces, India, with the approval of the C.-in-C. They are always kept in readiness for mobilisation—their stores being constantly used and renewed so that the stock is kept fresh at all times.

Field ambulances are placed in rear of the centre of the force to which they are attached. In British field ambulances are treated British officers, warrant officers, N.-C. O.'s and men of the European troops; and in Indian field ambulances are treated Native officers, N.-C. O.'s, men and followers.

The O. C. field ambulance sends all sick and wounded to the field ambulances on the lines of communication under instructions from the P. M. O. Field Force, keeping only such cases as will be fit for duty within a short time, or those who might suffer by removal.

If field ambulances become stationary ones, the latrine arrangements require the special attention of the O. C. of the hospital, otherwise they are almost certain to become endemic foci for the spread of enteric fever, dysentery, etc.

In stationary field ambulances disinfectants should be invariably used for the latrines, the medical officer on duty for the day should be held responsible that this is done systematically; and some arrangement should be made to incinerate the excreta of all patients suffering from enteric fever, dysentery and cholera. One has used shallow iron pans and kerosine oil tins for this purpose on more than one occasion, where more suitable arrangements could not be made.

"For all infectious diseases or diseases ordinarily so designated, separate the sick, largely increase the superficial area for the remainder, and change the site; this will be specially required in the case of cholera." One has repeatedly brought about the termination of epidemic infectious disease, and even cholera, by such complete separation of infected from healthy, and repeated change of site of camps.

Field ambulances on lines of communication.—Field ambulances on the lines of communication are equipped identically with those in the field, and in addition to temporarily locating sick and wounded from the front serve to treat the sick of the camp they are in.

General or base hospitals.— Although here referred to last it is necessary to establish general hospitals at the base of operations before or as soon after mobilisation of the force as possible. "Their establishment is the first step to attain a successful field medical organisation; this is accordingly effected, as far as possible, immediately after mobilisation is ordered, *i.e.*, before the troops concentrate. In the event of delay in their arrival, station, regimental, etc., hospitals may be used as temporary substitutes." (*F. S. M.*, *M.*, 1908, Sec. 11). One or more may have to be opened in different places. For the Thibet Mission there was one at Siliguri, another at Lebong, and a third in Calcutta (Alipore); during the Tirah Campaign there were two at Kohat and two at Rawalpindi. To these the sick and wounded from the front and lines of communication gravitate. The field ambulances at the front and in the lines of communication and the base general hospitals, form one integral whole, each, however, capable of working independently. It is only at the base hospitals that complete arrangements for the dieting, clothing, nursing, general and special care of the sick and wounded can be expected.

General hospitals form the seventh line of medical assistance on field service, and are for sick and wounded officers, soldiers, and followers detached from the army at the front and on the lines of communication. They are opened under such circumstances and at such places (base, lines of communication or other suitable localities) as may be deemed necessary. They are administered and worked generally as station hospitals. The number of beds for which each general hospital is equipped will, with the approval of the Commander-in-Chief in India, be decided by the P. M. O., H. M. F. in India. British European warrant officers, rank and file are admitted into British general hospitals; Native officers, rank and file and followers into Native general hospitals. In both also, European and Native officers and warrant officers receive separate accommodation.

Each general hospital is a 500 bed unit capable of division into five complete sections of 100 beds. Forty beds for British officers are included in a British general hospital.

The P. M. O. of a base or general hospital is under the officer commanding the base, and the P. M. O. lines of communication. The size of general hospitals is determined by the probable number of sick and wounded expected There will be one medical officer of lieutenant-colonel's rank with each general hospital of 500 beds, and with British base hospitals he will have under him nineteen, and in Indian base hospitals. eleven executive medical officers, one of whom in each case will act as registrar (combining the duties of secretary and statistical officer).

Buildings are utilised for general hospitals wherever practicable, otherwise the Ordnance Department supply the regulation number of

tents. When tents are used a hospital flag is hoisted to locate the hospital. This is also desirable even where villages or permanent buildings are used as general hospitals.

The hygienic rules regarding selection of sites, water-supply, nature of the soil, drainage of ground, etc., required regarding camps and billets, will, of course, be observed in the case of general hospitals, unless orders to the contrary are issued. Depôts for British and Native troops are formed in the neighbourhood of general hospitals for receiving men discharged from the hospitals, and to provide necessaries for those in the hospitals.

The medical officer in charge will, in the absence of a district P. M. O., exercise all the powers usually vested in the latter regarding provision of supplies, equipment, etc., but when the general hospital is within the jurisdiction of a district P. M. O., the medical officer in charge will be under his orders. He will superintend the treatment of the sick and wounded, and will detail such duties to the medical officers, subordinates and establishment at his disposal, as he may deem necessary.

Medical organisation of the Japanese Army.—It will be interesting here to note briefly in what respects the medical organisation of the Japanese Army differs from our own.

The Director-General of the Army Medical Service is under the Minister of War and is responsible for expenditure on medical services, preparation of estimates and general efficiency of medical services. His office is divided into two branches, each under a colonel; one branch deals with question of *personnel*, hygiene, statistics, professional and scientific subjects, and voluntary medical aid; the other with medical and surgical supplies, hospitals, transport of sick and wounded, mobilisation, etc., four officers of the medical service are attached as extra staff during war, usually from the staff of the Army Medical School, which is closed.

The administration of the medical service of the military districts (there are 12 such districts based on a territorial system) throughout Japan is carried out by principal medical officers of divisions, who are on the divisional staff. The P. M. O of divisions are usually colonels, but there are a certain number of surgeons-general, one surgeon-general being posted as P. M. O. to each of at least three territorial divisions In war the P. M. O. of a division is also a colonel, but the appointment may be held by a lieutenant-colonel. On mobilisation to form an Army in the field a P. M. O. is appointed as P. M. O. of the Army. He is a surgeon-general ranking with major-general. In the late war there were four or five surgeons-general in the field as P. M. O.'s of the several armies.

The administration of the medical service on a line of communication is carried out by a colonel who is on the staff of the Inspector-General of the line of communication. Each Field Army has its own line of communication, and there is one P. M. O. line of communication for each Field Army. As the lines of communication of Field Armies might at times converge into one line, there would be an additional P. M. O. for that line, but such a line would usually come into the command of a garrison of occupation and no longer form a portion of the Field Army.

In addition to the administrative control of the medical service in the field as represented by the P. M. O.'s of armies, divisions and lines of communication, a P. M. O. of the Field Forces is appointed as head of all the field medical organisation. He has authority over P. M. O's of Field Armies as regards professional duties, and his place is on the General Staff at Tokio. The appointment of P. M. O. Field Forces does not, of course, exist in time of peace, and is usually taken up on the outbreak of war by the Director-General of the Army Medical Service, for the time being another officer taking his place. In the late war he paid visits to Manchuria, in some cases for long periods. His duties, besides those of general supervision of the work of the medical services in the field, dealt with the medical details of the lines of communication in the Japan territory, and the distribution of sick and wounded returning from the front. All P. M. O.'s have two officers on their staff as Secretaries or Assistants. This applies to Divisional P. M. O.'s as well as to P. M. Os. of Armies. They have also a staff of clerks, who usually consist of three N. C. O.'s of the medical service. The staff of a P. M. O. is, however, somewhat elastic, and he can add to it under special circumstances.

The S. M. O. of regiments would in case of necessity act as P. M. O. of the brigade to which his regiment is attached.

In the late war there was no P. M. O. on the Staff of the Commander-in-Chief in the field. The administration and advisory duties of such an officer were performed by the Director-General Army Medical Service, acting as P. M. O. Field Forces, who worked with the General Staff in Tokio and visited the field occasionally.

When a division is mobilised and joins the Field Army, the whole of the peace staff is mobilized at the same time, and accompanies it into the field. Their place is taken by general and other officers of the service who are as a rule officers of the district on the retired list. In this way the Medical Service of the Depôt Division, as it is called, is administered during the war by a medical officer retired from the Army with the rank of Surgeon-General or Surgeon-Colonel.

The medical charge of the Head-quarters Staff of Armies and divisions is held by one or other of the Secretaries (or Assistants) of

the P. M. O. Sometimes the work is shared, the P. M. O. having full power to assign to his assistants such duties as he considers fit. A special medical officer has medical charge of the Commander-in-Chief and his staff. This medical officer has charge of the escort and followers of their respective Head-quarters, and performs the duties of sanitary officer for the locality in which the Head-quarters are situated. The duties of medical charge of brigade head-quarters staff are done by the nearest unit medical officer.

The medical charge of regimental units is held by a medical officer of rank below that of field officer. Each battalion of infantry has 2 medical officers; a regiment of artillery with 3 battalions has 6 medical officers; a regiment of cavalry consisting of 2 squadrons, 2 medical officers; a battalion of engineers, including telegraph company, 3 medical officers, and so on. A battalion of the train transport has 3 medical officers; an ammunition column 5, thus allowing for one medical officer to sections of companies of these units. All medical officers of units are mounted.

There is a staff of N.-C. O.'s, 1 to each company, plus one senior N.-C. O. who acts as chief assistant to the medical officer in the preparation of returns, care of medical and surgical equipment, etc. Each N.-C. O. carries a field medical companion or surgical haversack which has a compartment for splints, and also an Esmarch's elastic tube tourniquet which is carried round the waist.

The medical officers with units form regimental sick-rooms in encampments or cantonments, and relief or aid stations, temporary regimental or battalion stations, during an action. They have sanitary charge of the locality where their unit is stationed, including villages in the vicinity which are not occupied by other units. The equipment consists of four medical panniers, two of which go with the first line and two with the second line of regimental transport.

The medical officers of infantry battalions only have a staff of regimental stretcher-bearers. Each company is obliged to have four men trained in first aid to the wounded, and in the carriage of wounded by stretchers or by improvised means. These form the regimental stretcher-bearers—they are called assistant stretcher-bearers to differentiate them from the stretcher-bearers of the divisional bearer battalion. During an action they are placed under the medical officer of the unit, and on the line of march in the rear of the battalion, carrying their rifles. There are thus 16 per battalion—a unit has only 4 companies—one stretcher to 4 bearers which make a squad. Their duties are as in our Army. They are usually accompanied when at work by the company medical N.-C. O. The battalion medical officers seldom go beyond their own dressing station, although they would proceed into the fighting ranks if ordered to go there in connection with any special case.

Field medical units of Japanese Army.—The medical units in the field are as follows, arranged in order from front to base:—

1. Bearer Battalions.
2. Field Hospitals (Cantonment Hospitals, Rest Stations, Infectious Diseases Hospital).
3. Reserve Medical Personnel (Stationary Field Hospitals, Rest Stations, Infectious Diseases Hospital).
4. Sick and Wounded Transport units (Rest Stations).
5. Medical and Surgical Reserve Depôts.
6. Line of Communication Hospitals (Infectious Diseases Hospitals).
7. Hospital Trains.
8. Hospital Ships.
9. Military Quarantine Stations.
10. Reserve Hospitals (Infectious Diseases Hospitals).
11. Fortress Hospitals (Infectious Diseases Hospitals).

For our present purpose it is only necessary to deal with a few of these.

Field hospitals are divisional units. There are 6 field hospitals with each division, but during the recent war no division had more than 4, and some only 3 or 2. Field hospitals may be opened during an action, after an action, or during inactivity. Its equipment and *personnel* is in two halves exactly similar. These are only opened as required. The field hospital is organised and officered for the treatment of 200 sick and wounded at one time and reserve rations both for the *personnel* and patients are carried with it. The S. M. O., who is commanding officer, is a major and has under him 5 medical officers (captains or subalterns), 1 apothecary, 1 intendance officer or warrant officer, and 1 N.-C. O. of the train or transport battalion. A field hospital contaius no transport material for sick and wounded beyond a few stretchers. The number of panniers with medical and surgical equipment is 12, two sets of 6 panniers identically equipped. There are also 8 packages containing bedding and clothing for patients, the latter, consisting of a Japanese bed-gown and waist-belt. Tents may be carried, but the number depends on circumstances. In Manchuria 4 tents only per hospital were carried, chiefly as offices, reception and operation-rooms. The village houses supplied the necessary ward accommodation. The field hospital establishment has no concern with the actual carrying of the sick and wounded.

In opening a field hospital during an action a site is chosen as near the divisional dressing station as possible, one that is out of range

of fire, easily reached, and with facilities for the transport of wounded. Road indicators are put up if the site is concealed, or if the way is likely to be missed.

The Japanese work their field hospitals in distinct departments—administrative, admission and discharge, keeping statistical records, arms, accoutrements, money, valuables, etc , wards, operation-room, apothecary's department (for packing, unpacking and issue of medical and surgical material), kitchen, ablution department, mortuary, disinfection department, stables and wagon-park. The wards are subdivided according to the nature of the diseases and wounds.

The field hospitals are very mobile units and advance and retire with their divisions. The organisation of the various departments therefore is such that each has its own fixed *personnel* and there is no overlapping of work or confusion.

When a division is on the march and there is an accumulation of sick and foot-sore patients unable to march with the troops, a section of a field hospital may be ordered to open temporarily and form "Rest Stations" for these cases, taking care of them until they are sent back to a stationary field hospital or line of communication hospital.

When a division is cantoned during a period of inactivity, one or more field hospitals may be opened as a cantonment hospital for the division. They are then called cantonment hospitals, and named after the place (village or town) they are in. Any suitable buildings in the neighbourhood may be used for these hospitals, and placards posted to direct to them. Such hospitals continue the treatment of cases likely to be soon fit to return to the front. If cases are not likely to recover quickly they are sent back as soon as possible to the lines of communication hospitals.

When a division moves on, the cantonment hospital remains behind until its patients have all been sent back or handed over to a relieving reserve medical personnel, when it will rejoin its division—the move of the division is usually anticipated and the hospital prepared to advance with it.

Military quarantine stations.—Military quarantine stations were formed in connection with the ports of disembarkation for troops and others returning from the field. There were such stations at Moji, Ujina, Kobe, and all the troops and others arriving there had to pass through the disinfecting establishments of these stations previous to landing in Japan. A military quarantine station consists of a set of huts for the accommodation of troops in quarantine, a quarantine hospital, and a disinfecting establishment. This last is elaborately

organised in the most minute detail for cleansing the men by means of hot water body baths, and for disinfecting clothing, equipment, valuables, accoutrements, etc., by steam or formalin. The largest was near Ujina, the port of Hiroshima. It had two sections with accommodation for 6,000 troops each, disinfecting establishments capable of dealing with 8,000 men and their kits daily, and a quarantine hospital for 1,000 patients. This hospital had isolation and convalescent wards, and wards for acute cases. The diseases for which quarantine was required were—plague (10 days), cholera (5 days), yellow fever (5 days).

The quarantine stations had a large staff of medical officers and one for inspecting troops as they arrived, and for disinfecting them if necessary. Transports with scarlet fever, diphtheria, typhus fever and measles were also disinfected by the disinfecting staff from the quarantine stations, and the cases placed in the quarantine hospital.

As a rule, cases of dysentery and enteric fever, although regarded as infectious diseases and isolated, are taken to the infectious diseases section of the reserve hospitals and not to the quarantine hospitals, and the transports containing such cases were disinfected by the port authorities A military quarantine station is under the command or a retired *gendarmerie*; the disinfecting establishment under a senior medical officer; and the quarantine hospital under another senior medical officer. The establishments consist of recruits or other reserves for general work in the disinfecting establishment, and of Army Medical Service reserves or civil sick attendants in the quarantine hospitals.

Reserve hospitals.—All the sick and wounded that were sent back to Japan from the field, and the sick of local troops belonging to the depôt divisions, were admitted into and treated in hospitals called *reserve hospitals*. These institutions are simply the peace general hospitals at the Head-quarters of each division, but such hospitals have been constructed as a rule for about 400 to 600 beds only, and in time of war they are greatly enlarged. During the war some of these were expanded to contain from 10,000 to 15,000 patients. Sites were chosen in the vicinity and tents erected, each new site forming a section of the reserve hospitals. Such large hospitals were in Hiroshima, Tokio, Osaka, etc. One of them is under a lieutenant-colonel, with one medical officer to every 50 beds. These hospitals are equipped for every form of medical and surgical treatment. They have large and elaborately constructed operating rooms, bandaging rooms, kitchens, baths, photographic rooms, Rontgen-ray equipment, electric apparatus, laboratories for chemical analysis and bacteriological work, apothecary's department for the preparation of various drugs from the crude material. The sick and wounded from the front were sent to the reserve hospital of the territorial division to which they belong.

Infectious diseases hospitals.—Hospitals for the treatment of infectious diseases, in which dysentery and enteric fever are included, were formed on the area where the disease broke out. They are not separate units, organised as infectious hospitals, but one or more field hospitals or sections of such hospitals may be opened to form an infectious disease hospital. The object of the organisation of Japanese Army is to avoid moving infectious disease cases down the lines of communication, or to Japan, but to isolate them on the spot where the disease has been contracted. The infectious disease hospitals, therefore, form practically sections of their cantonment hospital or of line of communication and stationary field hospitals. They are not provided with any special apparatus for disinfection, but infectious material is burnt or treated with chemicals.

Evacuation of sick and wounded to base.—The Japanese organisation for evacuation of the sick and wounded is very complete and carried out by the units organised for that purpose.

These units are from front to base :—

1. The regimental or assistant stretcher-bearers.
2. The corps of divisional bearer battalions.
3. The sick and wounded transport department units.
4. Ordinary and hospital bearers.
5. Hospital stretchers.

Rest and refreshment stations are provided along the whole line of evacuation.

APPENDIX.

STATISTICS OF DISEASE, WOUNDS, ETC., IN INDIAN FRONTIER CAMPAIGNS.

Black Mountain Expedition, 1888.—The Black Mountain Expedition of 1888 was a particularly healthy one as regards disease. In it 2 British officers died of wounds, and 3 others were wounded. Three died of disease.

British and Native Troops: 18 killed, 5 died of wounds, 42 were wounded and only 7 died from diseases. *Followers:* 2 killed, 5 wounded, and 1 died of disease.

Chin-Lushai.—In the Chittagong column of the Chin-Lushai Expedition of 1889-90 "fever and dysentery were the most prevalent diseases. A large number of men also suffered from sores in the feet and legs, caused by wounds received from broken bamboos when marching through the jungle. These bamboos appeared to be most poisonous, and to lead to chronic ulcers and buboes in the groins."

Miranzai, 1891.—Miranzai Expedition, 1891, from 18th January to 25th February.

No European Troops took part in the Campaign.

Strength of Force.	Dysentery.	Ague.	Bronchitis.	Pneumonia	Injuries.	Frost-bite.	Total adms.	Deaths.	REMARKS.
Troops 4,899 ...	48	59	41	43	28	25	244	5	There was no fighting in this Expedition.
Followers 2,345 ...	26	18	19	12	25	8	108	1	
Grand Total 7,244 ...	74	77	60	55	53	33	352	6	

The absence of diarrhœa (3 cases in 7,244) is remarkable and was due to the excellent water obtained throughout. The expedition was of short duration and carried out under favourable conditions, yet it must be considered as successful from the few admissions and low death-rate, etc.

Chitral Relief Force, 1904.—In the *Chitral Relief Force* there were 1 British Officer and 16 Non-Commissioned Officers and men (including British and Native) killed in action; 12 British Officers and 69 Warrant Officers, Non-Commissioned Officers, and men wounded

of whom 4 died. The admissions from disease amongst British troops were 1,467. Their chief admissions for disease were:—Malarial Fevers 1,101, Dysentery 565, Diarrhœa 273, Enteric Fever 326, Venereal diseases 288. Amongst the Native troops there were 3,119 admissions from disease of an average strength of 4,581. The chief diseases were:—Malarial Fevers 1,025, Dysentery 607, Diarrhœa 193, Debility 182, Rheumatism 48.

Amongst followers the total admissions were 3,587 on a strength of 7,118, the chief diseases being the same as in the Native troops.

Malakand Expedition, 1897.—During the *Malakand Expedition* in August and September 1897, there were 830 European, and 1,129 Native soldiers admitted into hospital. The chief causes of admission into hospital were:—

European Troops.

Malarial Fevers	...	...	...	440	cases.
Dysentery and Diarrhœa		...	...	40	,,
Other diseases	...	...	...	300	,,
Wounded in action	...	...	...	20	,,

Native Troops.

Malarial Fevers	...	...	...	300	cases.
Dysentery and Diarrhœa		...	...	362	,,
Other diseases	...	...	...	321	,,
Wounded in action	...	...	...	146	,,

In the continuation of the same expedition from September to December, there were 2,246 European and 2,557 Native troops admitted into hospital.

The chief admissions were as follows:—

European Troops.

Malarial Fevers	...	...	...	1,351	cases.
Dysentery	...	...	...	100	,,
Enteric Fever	...	...	...	37	,,
Other diseases	...	...	...	708	,,
Gunshot wounds	...	...	...	50	,,

Native Troops.

Malarial Fevers	...	...	...	775	cases.
Dysentery	...	...	...	552	,,
Other diseases	...	...	...	902	,,
Gunshot wounds	...	...	...	328	,,

Malarial fevers and dysentery were the chief causes of admission amongst the followers.

Tirah Expedition, 1897-98.

	British Service strength.				Indian Service.				Total Troops.		Followers.		Grand Total.	
	Officers.		Troops.		British Officers.		Native Troops.							
Strength	397		8.266		292		16,220		25,175		11,929		37,104	
Daily sick	27·77		606·67		16·20		931·87		1582·65		699·50		2282·01	
Sick to strength per cent.	7·99		7·34		5·55		5·74		6·29		5·86		6·15*	
	Admitted.	Died.	Admitted.	Died.	Admitted.	Died.	Admitted.	Died.	Admitted.	Died.	Admitted.	Died.	Admitted.	Died.
Remittent and simple continued fever ...	23	...	248	4	13	...	165	13	449	17	102	16	551	33
Enteric fever	23	...	221	53	7	1	1	1	257	60	1	1	258	61
Ague	52	...	2.765	4	23	...	2,321	15	5.371	19	1,539	80	6,610	99
Dysentery	21	...	483	17	17	...	1 431	29	1,952	46	1,950	311	3.902	357
Venereal disease	2	...	541	...	...	...	235	...	778	...	287	...	1,065	...
Scurvy	...	...	...	...	...	...	42	...	42	...	23	...	65	...
Bronchitis	7	...	222	2	...	...	432	9	664	11	576	53	1,245	64
Pneumonia	1	...	50	9	8	...	189	50	340	59	226	109	576	188
Diarrhœa	22	...	304	3	8	...	365	3	899	14	333	81	1,292	95
Other complaints	62	2	1,199	17	30	...	1,496	21	2,887	41	1,415	57	4,292	98
Gunshot wounds	34	2	364	33	17	1	437	44	852	77	96	21	948	88
Deaths in action	...	14	...	100	...	9	...	98	...	221	...	...	...	221
Total ...	251	9	6,969	143	128	3	7,639	190	14,989	345	2,252	788	22,239	1,133

* These figures include the sick and wounded of the 1st and 2nd Division of the Peshawar Column, Kurram Movable Column, the Lines of Communication, and Nos. 1, 2, 3, and 4 General Hospitals.

Tirah Campaign, 1897-98.—In the Tirah Campaign of 1897-98 the number of admission and deaths among *followers* was very much more numerous than among troops.

	Admissions per 1,000 of strength.	Deaths per 1,000 of strength.
Troops	595·3	13·7
Followers ...	607·7	66·0

This high mortality amongst followers was chiefly due to pneumonia. There were 276 admissions from this, with 129 deaths.

Dysentery accounted for the highest number of admissions amongst the followers—1,950 with 311 deaths. Next comes ague, 1,539 cases with 30 deaths; then bronchitis, 576 with 76 deaths; then diarrhœa, 393 with 84 deaths.

Thibet Mission, 1904.—The greater portion of the sickness and deaths was attributable to the climate. The total number of deaths and men invalided up to September 30th, 1904, excluding war casualties, were 411 and 671 respectively, and of these 202 and 405 were due to climatic conditions.

	British Troops.	Native Troops.	Followers.	Total.
Total deaths excluding war casualties	4	102	305	411
Deaths due to climate	4	60	138	202
Invaliding, exclusive of war casualties	44	192	435	671
Invaliding due to climate ...	29	149	227	405

There was only one case of scurvy notwithstanding the frequent absence of fresh vegetables, the large ration of fresh meat having doubtless contributed to this happy result.

Amongst the British troops the principal diseases were—diarrhœa, bronchitis, rheumatism, remittent and enteric fevers. The causes of these diseases were respectively indigestible and insufficiently cooked food, cold and chill, malaria and heat of sun. The source of the enteric infection was not traceable.

The Native troops suffered most severely from intermittent fever. After this came bronchitis and pneumonia, then dysentery, diarrhœa, rheumatism and frost-bite. Snow-blindness, owing to the general use of neutral-tint glasses, was very rare and mild until the return march, when, snow-bound at Phari in October, about 200 cases occurred. Some cholera cases occurred in the Lower Tista Valley. The initial cause of the ague was doubtless infection brought from India as the disease occurred chiefly about at 2,000 feet above sea level after a chill, though in many cases it may have been contracted in passing through the malarial Terai, and lower gorges of the rivers.

Diarrhœa and dysentery were largely due to the difficulty of cooking food, owing to the low boiling point by the lessened atmospheric pressure at high altitudes, the scarcity of fuel, and the excessive cold; bronchitis and ague were due chiefly to exposure to the cold and the high altitude. They were especially common in Phari in the winter months, where the barracks were badly ventilated and filthy, whilst the acrid smoke of the argol fires irritated the respiratory passages. Frost-bite was common after the first heavy falls of snow, and was aggravated by the men placing their feet too close to the fires.

Followers suffered chiefly from ague, diarrhœa and dysentery, bronchitis, and pneumonia, from the same causes as the combatants. Many had also a good deal of debility, apparently from impoverished blood and continued work at high altitudes. It was observed that in the case of the 40th Pathans and 19th Panjabis, the chest underwent some expansion under the influence of high altitudes.

There were 161 killed in action and wounded. There was great variety in the wounds, as the Tibetans were armed with weapons of from the oldest pattern to the most modern. Sword wounds were numerous, and healed with wonderful rapidity. Contusion from stones were not uncommon. The Lhasa-made Martini pattern rifles (·550 bore) invariably inflicted severe wounds, the effects being like those of an explosive bullet. Matchlock wounds generally became septic, especially when the bullet lodged, and particularly when they were wrapped in dirty cloth or tin, to make them fit the bore. The wounds caused by the balls of the large *jinjals* in Gyantse, varying from 4 oz. to nearly 4 lbs. in weight, caused terrible wounds which were generally rapidly fatal.*

Medical statistics in Japanese Army during the late war.—Surgeon Lieut.-General U. Koike, Director-General, Japanese Army Medical Service, states that during the 21 months that intervened between the declaration of war and the restoration of peace, twenty battles, large and small, were fought, causing 220,812 casualties, of

* *Report of the Medical History of the Tibet Mission*, 1904, by Lt.-Col. E. Waddell, I.M.S., Principal Medical Officer with the Force.

which the details are as follows :—*Killed*—47,387, including 19 medical officers. *Wounded*—173,425, including 104 medical officers ; and 450 rank and file of the Bearer Corps were killed and wounded.

The total number of sick admitted to hospitals amounted to 236,223, of that number 27,158 were infectious diseases. In addition to the foregoing there were 97,850 sick admitted to hospital from mobilised units in Japan and in Formosa, the grand total of killed, wounded, and sick, therefore, amounted to 554,885. If the 77,803 sick and wounded Russian prisoners treated in the Japanese hospitals are added, the total number reaches 632,688. In the treatment of the above there were employed, 4,517 Army Medical Officers. Of this number 2,829 were called out after the outbreak of the war. There were 639 Army Pharmacists (Officers), including the Principal Pharmacist of the Forces ; 487 of these were called out during the war.

Men employed.—There were 7,322 chief nurses, 4,144 assistant nurses, 21,797 attendants ; 334 men were employed in the care of the medical and surgical instruments. There were also 5,479 members of the Japanese Red Cross Society employed, including 373 doctors, 175 pharmacists, the remainder perfectly trained male and female nurses.

Medical and surgical material.—" Never once during the whole war did we experience a shortage of material. On the contrary we had always an abundance in all the Armies, and all the materials used were from the Army Medical and Surgical Supply Depôt. Nearly 3,000 packets of these materials were used, costing about £710,000. The 'Invasion of Russia Pills'—creosote pills for preventing internal diseases—were manufactured in Tokio, and the dressings and bandages made by the members of the Ladies' Benevolent Society and other Societies."

Transport of sick and wounded.—The most severe task of the Medical Service was the transport of the sick and wounded to the rear. Fortunately they were able to use the railway line which the Russian Army had left untouched.* The details are both interesting and highly instructive, but do not enter the province of preventive measures to which we limited ourselves.

Treatment of Japanese sick and wounded.—The percentage to recoveries of all sick and wounded admitted into hospitals from all units at the seat of war, in Japan, and in Formosa, was 63·23, while the deaths were 7·49 per cent. The percentage of recoveries of all sick and wounded of the troops at the seat of war was 71·58, and of deaths 6·83.

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* One is indebted to the *Journal of the Royal Army Medical Corps*, December 1906, p. 624, *et seq*, for this information.

Comparing these percentages with those in the time of peace at the end of 1903, the following statements are given :—

	Peace Time.	War Time.
Recoveries ...	... 75·05 per cent.	63·23 per cent.
Deaths ...	... 118 ,,	7·49 ,,
Recoveries ...	...	71·58 ,,
Deaths ...	...	6·83 ,,

A profoundly interesting table follows, comparing the above statistics with those of the Chino-Japan War.

		Chino-Japan War.	Russo-Japan War.
Of all the units in Japan and at seat of war.	Recoveries ...	50·94 per cent.	63·23 per cent.
	Deaths ...	11·24 ,,	7·49 ,,
Units at the seat of war only.	Recoveries ...	54·81 ,,	71·58 ,,
	Deaths ...	7·65 ,,	6·83 ,,

The reason given for the comparatively similar death-rate in both campaigns is that "the Chinese run away at sight, whereas the Russians made so stubborn a resistance that a battle sometimes lasted a fortnight, and forced the Japanese to transport the wounded under cover of night, besides which, being short-handed, they conveyed the wounded under conditions the urgency of which interfered with proper treatment."

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